PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 29 June 2000 (29.06.00)	
International application No. PCT/SI99/00024	**Applicant's or agent's file reference** 218-P06PC/99
International filing date (day/month/year) 25 October 1999 (25.10.99)	**Priority date** (day/month/year) 26 October 1998 (26.10.98)
Applicant PIRS^¿, Janez et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

25 May 2000 (25.05.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Antonia Muller
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
218-P06PC/99		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/SI 99/00024	25/10/1999	26/10/1998
Applicant		
PIRS, Janez et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 04 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [X] **Unity of Invention is lacking** (see Box II).

4. With regard to the **title,**

   [ ] the text is approved as submitted by the applicant.

   [X] the text has been established by this Authority to read as follows:

   DRIVING SCHEME AND ELECTRONIC CIRCUITRY FOR A LCD ELECTRO-OPTICAL SWITCHING ELEMENT

5. With regard to the **abstract,**

   [ ] the text is approved as submitted by the applicant.

   [X] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 5

   [X] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/SI 99/00024

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G02F1/133 G09G3/36 A61F9/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G02F G09G A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 205 311 A (KUTARAGI KEN) 27 May 1980 (1980-05-27) column 4, line 42 -column 5, line 48; figures 8-10 ---	1,3,4,6, 9
A	"METHOD TO MEASURE AND REDUCE UNBALANCED DC VOLTAGE IN ACTIVE MATRIX LCDS" IBM TECHNICAL DISCLOSURE BULLETIN,US,IBM CORP. NEW YORK, vol. 35, no. 3, 1 August 1992 (1992-08-01), pages 162-164, XP000326220 ISSN: 0018-8689 the whole document --- -/--	1,3,5,6

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 June 2000	15.06.00

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Stang, I

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 07, 31 July 1996 (1996-07-31) & JP 08 082785 A (SONY CORP), 26 March 1996 (1996-03-26) abstract	1,10
A	WO 87 01468 A (CONS TECHNOLOGY PTY LTD) 12 March 1987 (1987-03-12) page 8, line 3 -page 9, line 2; figures 4,5	1,3,5
A	EP 0 550 384 A (XELUX AG) 7 July 1993 (1993-07-07) cited in the application the whole document	1,3
A	WO 92 16820 A (OSD ENVIZION COMPANY) 1 October 1992 (1992-10-01) cited in the application page 6, line 14 -page 7, line 20	1,3-10
X	US 3 961 840 A (SHIGURI MOROKAWA ET AL) 8 June 1976 (1976-06-08) column 1, line 23 - line 68 column 3, line 37 -column 6, line 39; figures 2F-6	2
A	US 4 279 474 A (BELGOROD BARRY M) 21 July 1981 (1981-07-21) column 6, line 35 -column 7, line 18; figure 7	2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SI 99/00024

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SI 99/00024

Box III TEXT OF THE ABSTRACT (Continuation of item 5 of the first sheet)

The invention relates to the problem of the driving of the LCD electrooptic-switching element(1) with alternating, square-wave electric signals, the amplitude of witch can vary between different voltage levels in correspondence with the actual functioning state of the LCD electrooptic-switching element. The polarity changes of the electric driving signals is controlled by the integrator(9), integrating the difference of the electric potentials on the driving electrodes(2,3) of the LCD electrooptic-switching element, in such a way that the value of time integral of the driving electric field is always kept within a selected interval. Besides this the time dependence of the electric driving signals can be optionally modified so that with every change of the polarity of the electric driving signals, the potentials on both driving electrodes get the same value for a time, wich is significantly shorter than the switching time of the LCD electrooptic-switching element.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1,3-10

   LCD driving scheme in which the changing of polarity is controlled by an integrator

2. Claim : 2

   LCD driving scheme in which both electrodes are connected to the same electric potential for a certain period of time

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/SI 99/00024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4205311 A	27-05-1980	JP 1228389 C	19-09-1984
		JP 54044558 A	09-04-1979
		JP 59003730 B	25-01-1984
		AU 525508 B	11-11-1982
		AU 3978678 A	20-03-1980
		CA 1120621 A	23-03-1982
		DE 2840034 A	29-03-1979
		FR 2403612 A	13-04-1979
		GB 2004401 A,B	28-03-1979
		NL 7809309 A	16-03-1979
JP 08082785 A	26-03-1996	NONE	
WO 8701468 A	12-03-1987	AU 6338586 A	24-03-1987
		EP 0236361 A	16-09-1987
EP 0550384 A	07-07-1993	CH 687909 A	27-03-1997
		AT 158711 T	15-10-1997
		DE 9219117 U	20-05-1998
		DE 59208946 D	06-11-1997
		DK 550384 T	18-05-1998
		US 5315099 A	24-05-1994
WO 9216820 A	01-10-1992	US 5252817 A	12-10-1993
		EP 0531504 A	17-03-1993
		US 5751258 A	12-05-1998
		US 5248880 A	28-09-1993
US 3961840 A	08-06-1976	JP 1142103 C	13-04-1983
		JP 50006356 A	23-01-1975
		JP 57031148 B	02-07-1982
		DE 2423675 A	28-11-1974
		GB 1471219 A	21-04-1977
		HK 30082 A	09-07-1982
US 4279474 A	21-07-1981	AU 7154281 A	09-10-1981
		CA 1152367 A	23-08-1983
		DE 3140603 T	22-04-1982
		EP 0048266 A	31-03-1982
		GB 2083649 A,B	24-03-1982
		IT 1144492 B	29-10-1986
		JP 57500394 T	04-03-1982
		JP 59026007 B	23-06-1984
		WO 8102795 A	01-10-1981

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

To:
ITEM, poslovno svetovanje, d.o.o.
Resljeva 16
1000 Ljubljana
SLOVENIA

Applicant's or agent's file reference 218-P06PC/99	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/SI 99/00024	International filing date *(day/month/year)* 25/10/1999
Applicant PIRS, Janez et al.	
	Date of mailing *(day/month/year)* 15/06/2000

1. [X] The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Fascimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Gregory Adam

Form PCT/ISA/220 (July 1998)

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions, respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international publication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When?

Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How?

Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped),whether

(i) the claim is unchanged;

(ii) the claim is cancelled;

(iii) the claim is new;

(iv) the claim replaces one or more claims as filed;

(v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."

2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."

3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."

4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international application is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments and any accompanying statement, under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the time of filing the amendments (and any statement) with the International Bureau, also file with the International Preliminary Examining Authority a copy of such amendments (and of any statement) and, where required, a translation of such amendments for the procedure before that Authority (see Rules 55.3(a) and 62.2, first sentence). For further information, see the Notes to the demand form (PCT/IPEA/401).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
218-P06PC/99		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/SI 99/00024	25/10/1999	26/10/1998
Applicant		
PIRS, Janez et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 04 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

[ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

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[ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

[ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [X] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

[ ] the text is approved as submitted by the applicant.

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DRIVING SCHEME AND ELECTRONIC CIRCUITRY FOR A LCD ELECTRO-OPTICAL SWITCHING ELEMENT

5. With regard to the **abstract,**

[ ] the text is approved as submitted by the applicant.

[X] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 5

[X] as suggested by the applicant.

[ ] None of the figures.

[ ] because the applicant failed to suggest a figure.

[ ] because this figure better characterizes the invention.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/SI 99/00024

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G02F1/133 G09G3/36 A61F9/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G02F G09G A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of box C.

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 June 2000	15.06.00

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Stang, I

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	EP 0 550 384 A (XELUX AG) 7 July 1993 (1993-07-07) cited in the application the whole document	1,3
A	WO 92 16820 A (OSD ENVIZION COMPANY) 1 October 1992 (1992-10-01) cited in the application page 6, line 14 -page 7, line 20	1,3-10
X	US 3 961 840 A (SHIGURI MOROKAWA ET AL) 8 June 1976 (1976-06-08) column 1, line 23 - line 68 column 3, line 37 -column 6, line 39; figures 2F-6	2
A	US 4 279 474 A (BELGOROD BARRY M) 21 July 1981 (1981-07-21) column 6, line 35 -column 7, line 18; figure 7	2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SI 99/00024

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

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1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SI 99/00024

Box III TEXT OF THE ABSTRACT (Continuation of item 5 of the first sheet)

The invention relates to the problem of the driving of the LCD electrooptic-switching element(1) with alternating, square-wave electric signals, the amplitude of witch can vary between different voltage levels in correspondence with the actual functioning state of the LCD electrooptic-switching element. The polarity changes of the electric driving signals is controlled by the integrator(9), integrating the difference of the electric potentials on the driving electrodes(2,3) of the LCD electrooptic-switching element, in such a way that the value of time integral of the driving electric field is always kept within a selected interval. Besides this the time dependence of the electric driving signals can be optionally modified so that with every change of the polarity of the electric driving signals, the potentials on both driving electrodes get the same value for a time, wich is significantly shorter than the switching time of the LCD electrooptic-switching element.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1,3-10

   LCD driving scheme in which the changing of polarity is controlled by an integrator

2. Claim : 2

   LCD driving scheme in which both electrodes are connected to the same electric potential for a certain period of time

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/SI 99/00024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4205311 A	27-05-1980	JP 1228389 C	19-09-1984
		JP 54044558 A	09-04-1979
		JP 59003730 B	25-01-1984
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PATENT COOPERATION TREATY

REC'D 03 APR 2001
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PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

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Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
218-P06PC/99		

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/SI99/00024	25/10/1999	26/10/1998

International Patent Classification (IPC) or national classification and IPC
G02F1/133

Applicant
PIRS, Janez et al.

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 7 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 10 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
25/05/2000	08.02.01

Name and mailing address of the international preliminary examining authority:

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/SI99/00024

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:
Description, pages:

1,4-18	as originally filed			
2,2a-2b,3,3a	as received on	11/11/2000	with letter of	06/11/2000

Claims, No.:

1-9	as received on	11/11/2000	with letter of	06/11/2000

Drawings, sheets:

1/9-9/9	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☒ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)
   see separate sheet

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-9
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-9
Industrial applicability (IA)	Yes:	Claims	1-9
	No:	Claims	

2. Citations and explanations
   see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Re Item I

1 The general description of the invention as originally filed was replaced by a new statement (page 3a: "The scope and the goal of the invention ...") that introduces novel subject-matter. In particular, the statements related to the "two polarity reversals" (page 3a) are not unambiguously derivable from the original application documents (Article 34 (2)(b) PCT).

Re Item V

2 The documents cited in the international search report will be named D1-D8.

3 The claims are unclear to such an extent (see section VIII) that only a preliminary opinion can be given as to whether the application meets the requirements of Articles 33(2) and (3) PCT and Rule 13.1 PCT.

3.1 It appears that claims 1 and 2 relate to a method of DC balancing a liquid crystal element (cf. the penultimate paragraph on page 4). Having regard to this aspect the following is noted.

3.2 The document D2 (IBM Technical Disclosure Bulletin) discloses a method and a corresponding circuit for DC balancing a liquid crystal element wherein the potential difference between the two electrodes of a liquid crystal element is integrated ("A1", "A2", "low pass filter A3") and used to "automatically adjust it nearly to null" (see also last sentence on page 163).

3.3 The documents D1 (US 4 205 311) and D3 (English language abstract of JP 8 082 785) both disclose a method and circuit for DC balancing a liquid crystal element wherein the voltage at one of two electrodes of a liquid crystal element is integrated and applied to the second electrode so as to Dependent claim-balance the liquid crystal element. In particular, in the circuit of document D1 (see figure 9) the driving signal supplied to the liquid crystal element 1 by the impedance converter 11 adapts its value and its polarity so as to minimize the DC component applied to the liquid crystal element.

3.4 Hence, the problem of DC balancing of a liquid crystal element is solved in the prior art in a manner similar to the method of claims 1 and 2. Insofar as these claims can be understood, they thus seem to lack an inventive step (Article 33(3) PCT).

3.5 Moreover, it seems that the circuits of claims 3-9 solve the same problem in a similar way and differ from the circuits of the cited prior art merely in the details of the implementation. However, the use of standard circuit parts for their intended purpose is considered to fall within the competence of a skilled person (Article 33(3) PCT). Moreover, the independent claims 3, 5, and 6 are considered not to be linked by a single general inventive concept (Rule 13.1 PCT).

3.6 Having regard to another aspect of the present application (last paragraph on page 4), it is noted that the document D7 teaches to short-circuit the electrodes of a liquid crystal elements during every change of polarity of the driving signals in order to reduce energy consumption.

Re Item VII

4 The features of claims 1 and 2 are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

Re Item VIII

5 The application does not meet the criteria of Article 6 PCT for the following reasons.

5.1 The three independent claims 3, 5, and 6 directed at electronic circuitry overlap in scope and comprise a plurality of mutually exclusive features (Rule 6.4 (a) PCT). Hence, the set of claims is not concise (PCT Guidelines III, 5.1) and it is not clear which features are essential features of the invention (PCT Guidelines III, 4.4).

5.1.1 In order to overcome this objection, it would appear appropriate to file an amended set of claims defining the relevant subject-matter in terms of a **single** independent claim in each category followed by dependent claims covering features which are merely optional (Rule 6.4 PCT).

5.2 The claims 1 and 2 seem to relate to a method of driving a liquid crystal element. However, no method steps can be identified in these claims. Furthermore, it is not clear which features or results to be achieved are intended to be defined in lines 9-11 of claim 1 and in lines 17-21 of claim 2.

5.3 It would appear that the newly filed claim 2 is vaguely related to the aspect of the drive scheme described on page 9, second paragraph. According to that section of the description, the reference voltage level V_{c1} is changed "according to the signal generated by the sensor 35" such that "the time-intervals of the polarity changes of the electric driving signals are as uniform as possible". However, no features corresponding to the sensor signal can be identified. It would therefore also appear that this claim does not meet the requirements of Article 34 (2)(b) PCT.

5.4 The meaning of the reference to a feature is not clear without an antecedent definition of the feature. However, such unclear references are used throughout the set of claims (see, for example, claim 3: "the electric driving signals", "the electrodes", "the difference inputs", "the differential amplifier" etc.), rendering obscure which features the claims comprise. This objection applies to the method claims 1 and 2 in a similar manner.

5.4.1 In order to overcome this objection, it seems necessary to clearly define which circuit elements the circuit comprises and then to define the interrelationship of those elements.

5.5 Expressions or terms without well defined meaning are used throughout the set of claims. For example, the meaning of expressions like "the first even change of polarity" (claim 2, line 17) or "optimum dynamics of the electrooptic response" (claim 1, lines 4-5) is obscure.

5.6 Throughout the set of claims, several structural features are can be distinguished from each other solely by their reference signs (for example, claim 3, "the electrodes (2) and (3) ..."), which is confusing and does not meet the requirements of Rule 6.2 (a) PCT. The use of similar or identical wording to refer to different structural features should therefore be avoided.

5.7 The reference to the spirit of the invention (page 18, last line) implies that the subject-matter for which protection is sought may be different to that defined by the claims, thereby resulting in a further lack of clarity (Article 6 PCT) when used to interpret them (see also the PCT Guidelines, III-4.3a).

which significantly reduces the consumption of the electric energy in such a way that the automatic turn-off is no longer needed (Gunz, Ghisleni, EP 550,384, US 5,315,099). While the former patent application does not represent any significant novelty and is not solving the problem of the electric power consumption satisfactorily, the later solution is technically very important. ~~Its basic deficiency lies in the fact that it cannot be used with the frequencies above 0.3Hz when the transient phenomena, which accompany the low frequency driving, become too apparent and distract the user (noticeable time variations of the light attenuation).~~ Since it is not possible to synchronize the driving signals at such low frequencies with the time periods when the LCD electrooptical element has to be in the closed state (for example: welding), the above described LCD light shutter and the electric driving technique cannot provide a complete compensation of the DC component of the electric driving voltage, resulting in the reduced life time of the LCD electrooptic switching elements. The authors of the patent application EP 550,384 diminish this problem by changing the phase of the electric driving signals with every activation of the LCD electrooptical element, which only reduces the consequences and does not represent a reliable solution of the problem. Another known solution proposed by Fergason, US 5,347,383, US 5,252,817 uses the dual-frequency driving, the frequency being dependent on the optical state that the electrooptical switching element currently occupies. This allows for the quick changing of the polarity of the electric driving signals when the filter is in the optically open state (reduced flickering of the filter) and slow changing when the filter is optically closed and the flickering is not so pronounced. The consumption of the electric energy is therefore reduced, however only in one optical state, which does not represent the optimal solution of the problem of the consumption of the electric energy.

- The increased switching speed of the LCD electrooptic switching elements is generally achieved by using the high amplitude of the electric driving signals (Heimeier, US 3,575,491, US 3,731,986). The optimal results can be achieved by using the appropriate time dependence of the amplitude of the electric driving signals for the LCD electrooptic switching elements (Fig.1) as disclosed in the patent application (Toth, EP 0,157,744). According to this technical solution the LCD electrooptic switching element is already in the "open state", driven with the electric signals, the amplitude of which is smaller than the voltage threshold required for the electrooptical switching. The switching speed to the closed state of the LCD electrooptical-switching element is therefore significantly increased. The amplitude of the electric driving signals is very high immediately after the activation and decreases to the voltage level, which is required to maintain the required optical light attenuation.

Solving the problem of the low power consumption by using slowly varying electric driving signals seems to be the best general technical solution at present. However the use of such driving schemes results in several new problems that have not been adequately solved so far:

- Synchronization of the driving signals with the time intervals, when the LCD electrooptic switching element has to be in the optically closed state (for example: welding),
- Efficient compensation of the long-term DC component of the electric driving signals,
- Electric driving field screening due to the ionic conductivity effects in liquid crystals (variations of light attenuation in the optically closed state of the LCD electrooptic switching element,
- Electric driving field screening due to the electric potential build-up at the orienting polymer/liquid crystal interface - "residual DC".

In their patents (EP 550,384, US 5,315,099) Gunz and Gisleni manage to solve the above-specified problems only partially:

As they cannot avoid the adverse effects of the long-term DC component of the electric driving signals, Gunz and Gisleni suggest the use of additional protective layers in the LCD light shutter (US 5,315,099). The gradual build-up of the DC component of the electric driving signals results in pronounced light attenuation variations in the closed state of the LCD electrooptic switching element (for example: welding) due to the screening of the electric field caused by the above mentioned "residual DC" effect. As the result of this the technical solution, as proposed by Gunz and Gisleni, cannot be used with the frequencies above 0.3 Hz (typically), since the electric field screening phenomena become too apparent and distract the user.

The problems, related to the build-up of the long-term DC component of the electric driving signals, also cannot be adequately solved by the standard long-term DC component compensation techniques, disclosed in the patents (US 4,205.311, JP 08082785) and published in the IBM technical disclosure bulletin **35,** 3, Aug. 1992 as well as in SID Digest **20**, 226, 1989. All these techniques are based on the formation of a mean DC voltage, connected to one of the two electrodes of the LCD electrooptic-switching element. This "mean DC voltage" is selected in such a way that the long-term DC component of the electric driving signals is eliminated. It is generated by the integration of the electric driving signal over a longer time interval (i.e. large number of the electric driving signal periods). Therefore such a solution is not very applicable in the case of fast, strong transient "DC effects", which are characteristic for many applications (for example: welding), when using electric driving signals with slowly varying polarity. Due to a slow response of the "mean DC voltage" generating system, it takes quite some time before the DC component, built-up during the transient effect, averages out. Therefore the "residual DC" effects, as described above, can become very pronounced and can distract the user. Furthermore the above-described technique reduces the effective amplitude of the electric driving signal for the LCD electrooptic switching element by a factor of 2. This can be an important obstacle in cases, when high switching speeds are required (for example: welding).

~~The scope and the goal of the invention is the electronic driving scheme as well as the~~ adequate electronic circuitry for the driving of the LCD electrooptic switching elements with the following characteristics:

- Long-term autonomous operation, independent of the outside electric energy sources
- Optimization of the electric driving signals in the sense of the fast switching dynamics
- Optimization of the electric driving signals in the sense of maximizing the life time of the LCD electrooptic switching elements
- Optimization of the electric driving signals in the sense of minimization of the electric power consumption

~~According to the invention the problem is solved using independent patent claims.~~

INSERT PAGE 3a

Following is a detailed description of the preferred embodiments of the invention further described by means of the annexed drawings:

Fig. 1. - Multilevel time dependence of the amplitude of the electric driving signals allowing for the maximum switching speed

Fig. 2a - Symmetric, square-wave, periodic, alternating electric driving signals for the LCD electrooptic-switching element

Fig. 2b - Irregular electric driving signals for the LCD electrooptic switching element, having the long-term DC component equal to zero

Fig. 3. - Block diagram of the electronic circuitry, allowing for the compensation of the long-term DC component of the electric driving signals based on the complete time integral of the difference of the driving electric potentials across the LCD electrooptic switching element

Fig. 4. - Time-dependence of the most essential electric signals of the electronic circuitry in the Fig. 3.

Fig. 5. - Block diagram of the electronic circuitry, allowing for the compensation of the long-term DC component of the electric driving signals, based on the "partial" time integral of the difference of the driving electric potentials across the LCD electrooptic switching element

Fig. 6. - Time-dependence of the most essential electric signals of the electronic circuitry in the Fig. 5.

The scope and the goal of the invention is the electronic driving scheme as well as the adequate electronic circuitry for the driving of the LCD electrooptic switching element that will offer the best compromise between low electric power consumption (-slowly varying electric driving signals), fast switching dynamics, stable light attenuation and long life time of the products resulting from the efficient reduction of the long term DC component of the electric driving signals for the LCD electrooptic switching element. The proposed technical solution, based on the integration of the driving voltage between the electrodes of the LCD electrooptic switching element, is specifically characterized in that it:

- Not only allows for the complete annihilation of the long-term DC component of the electric driving signals for the LCD electrooptic switching element, but also allows for the "short term" DC electric driving voltage compensation within every period of the electric driving signal polarity change (two polarity reversals),
- Allows for the use of the multilevel electric addressing (see Fig 1) of the LCD electrooptic switching element, using high switching pulse amplitudes to increase the dynamic response of the LCD electrooptic switching element, as the proposed driving scheme allows for the fast "DC balancing" of the electric driving signals within two polarity reversals (-DC balancing cycle), irrespectively of the time variations of the driving voltage amplitude.

The problem is solved according to independent patent claims.

Patent claims

1. The driving scheme for the LCD electrooptic element with alternating square-wave electric signals, the amplitude of which can vary between different electric levels so that the optimum dynamics of the electrooptic response is assured, characterized in that the changing of the polarity of the electric driving signals is controlled by the integrator, which integrates the potential difference between the electrodes of the LCD electrooptic switching element so that it keeps the value of the time integral I_{nt} of the driving voltage within the predetermined interval ($V_{C1} \leq I_{nt} \leq V_{C2}$), determining the time interval for the polarity change of the electric driving signals as well as allowing for the complete annihilation of the long-term DC component of the electric driving signals for the LCD electrooptic switching element.

2. The driving scheme for the LCD electrooptic switching element as claimed in claim 1, characterized in that in the case that the amplitude of the of the electric driving signals for the said switching element is changing in time, the said predetermined interval (V_{C1}, V_{C2}) for the time integral I_{nt} of the potential difference between the electrodes of the LCD electrooptic switching element is synchronously with the first even change of the polarity of the said electric driving signals, which corresponds to a completion of the DC driving voltage compensation cycle and follows the amplitude change, adjusted according to the electric driving signal amplitude variation in such a way that the time interval of the electric driving signals polarity changes remains as constant as possible.

3. The electronic circuitry for the implementation of the driving scheme of claim 1, characterized in that the electric driving signals on the electrodes (2) and (3) of the LCD electrooptic switching element (1) are connected to the difference inputs (4) and (5) of the differential amplifier (6), the output signal (7) of which is connected to the input (8) of the integrator (9) and

that the output signal (10) of the integrator (9) is connected to the comparator inputs (12) and (22) of the comparators (13) and (20), the reference inputs (11) and (21) of which are connected to the electric potentials V_{C2} and V_{C1} respectively, while the signals, generated at the outputs (14) and (23) of the comparators (13) and (20), enable the control over the logic control signals for the LCD electrooptic switching element (1) via the "set/reset" inputs (16) and (15) of the control "flip/flop" circuit (17) so that the electric driving signals for each of the electrodes of the LCD electrooptic switching element (1), generated at its outputs (18) and (19) are phase shifted by 180° (Q/ $\bar{Q}$) and

that these logic control signals are connected to the inputs (39) and (40) of the voltage translator (36), which transforms them into the driving signals for the LCD electrooptic switching element (1) at its outputs (37) and (38) connected to the control electrodes (2) and (3) of the LCD electrooptic switching element (1), the amplitude of these driving signals being determined by the voltage level V_{LCD}, which is connected to the control input (41) of the voltage translator (36) and

that the said electronic driving circuitry can be optionally complemented with the electronic circuitry for the reduction of the time-interval variations of the polarity change of the electric driving signals for the LCD electrooptic switching element (1)

4. The electronic circuitry for the implementation of the driving scheme of claims 1 and 2 as claimed in claim 3, characterized in that it reduces the time-interval variations of the polarity change of the electric driving signals by means of using the additional analog switch (24) that selects between the voltage levels V_{S1} and V_{S2}, connected to the inputs (27) and (28) of the said analogue switch so that it changes the reference voltage V_{C1} at its output (25), connected to the reference input (21) of the comparator (20) and

that the selection of the reference voltage is made synchronously with the adequately selected driving signal for the LCD electrooptic switching element (1) and according to the signal given by the sensor element (35) so that the signal, which is generated by the sensor (35) at its output (34), connected to the synchronization input (31), synchronizes the logic control circuitry (30) in such a way that the logic signal at its output (32), connected to the control input (26) of the analogue switch (24), controls the said analogue switch in such a way that it selects the voltage level V_{C1} at its output (25), connected to the reference input (21) of the comparator (20), so that the time-interval variations of the polarity change of the electric driving signals, controlled by the comparator (20), are as small as possible.

5. The electronic circuitry for the implementation of the driving scheme of claim 1, characterized in that the electric driving signals on the electrodes (2) and (3) of the LCD electrooptic switching element (1) are connected to the inputs (49) and (50) of the analogue switch (48), the output signal (51) of which is connected to the input (8) of the integrator (9) and

that the output signal (10) of the integrator (9) is connected to the comparator input (56) of the comparator (54), the reference input (55) of which is connected to the electric potential V_C, while the signal generated at the output (57) of the comparator (54) enables the control of the logic driving signals for the LCD electrooptic switching element (1) via the input (16) of the control "flip/flop" switching circuit (17) so that the electric driving signals for each of the electrodes of the LCD electrooptic switching element (1), generated at its outputs (18) and (19) are phase shifted for 180° (Q/ $\bar{Q}$) and that at the same time the output (19) of the switching electronic circuitry (17) is connected to the control input (58) of the analog switch (48), selecting one of the driving electric voltages of the LCD electrooptic switching element (1) and that the output (57) of the comparator (54), is connected to the select input (61) of the analog switch (60), so that with every change of the polarity of the electric driving field between the electrodes of the LCD electrooptic switching element (1) the said analogue switch (60) switches for a short time its output (53), connected to the input (52) of the of the integrator (9), from its electrically floating input (62) to the adequately chosen constant electric potential, connected to its input (63), which results in resetting the integrator (9) to the initial state and

that the logic driving signals at the outputs (18) and (19) of the switching logic circuitry (17) are connected to the inputs (39) and (40) of the voltage translator (36) that transforms them on its outputs (37) and (38), connected to the electrodes (2) and (3) of the LCD electrooptic switching element (1), into the electric driving signals for the said LCD electrooptic switching element (1), the amplitude of which being determined by the electric voltage V_{LCD}, connected to the control input (41) of the voltage translator (36) and

that this electronic circuitry can be optionally complemented with the electronic circuitry for the reduction of the time-interval variations of the polarity-change of the electric driving signals for the LCD electrooptic switching element (1)

6. The electronic circuitry for the implementation of the driving scheme of claim 1, characterized in that the voltage output (43) of the analogue switch (42) which is apart from being connected to the input (41) of the voltage translator (36), connected also directly to the input (8) of the integrator (9) and

that the output signal (10) of the integrator (9) is connected to the comparator input (56) of the comparator (54), the reference input (55) of which is connected to the electric potential V_C, while the signal generated at the output (57) of the comparator (54) enables the control of the

logic driving signals for the LCD electrooptic switching element (1) via the input (16) of the control "flip/flop" switching circuit (17) so that the driving signals for each of the electrodes of the LCD electrooptic switching element (1), generated at its outputs (18) and (19) are phase shifted for 180° (Q/ $\bar{Q}$) and

that the output (57) of the comparator (54) is connected to the select input (61) of the analogue switch (60) so that with every change of the polarity of the electric driving field between the electrodes of the LCD electrooptic switching element (1) the said analogue switch (60) switches for a short time its output (53), which is connected to input (52) of integrator (10), from its electrically floating input (62) to the adequately chosen constant electric potential V_p, connected to its input (63), which results in resetting the integrator (9) to the initial state and

that the logic driving signals at the outputs (18) and (19) of the switching logic circuitry (17) are connected to the inputs (39) and (40) of the voltage translator (36) that transforms them on its outputs (37) and (38), connected to the electrodes (2) and (3) of the LCD electrooptic switching element (1), into the electric driving signals for the said LCD electrooptic switching element (1), the amplitude of which being determined by the electric voltage V_{LCD}, connected to the control input (41) of the voltage translator (36) and

that this electronic circuitry can be optionally complemented with the electronic circuitry for the reduction of the time-interval variations of the polarity-change of the electric driving signals for the LCD electrooptic switching element (1).

7. The electronic circuitry for the implementation of the driving scheme of claims 1 and 2 as claimed in claims 5 and 6, characterized in that it reduces the time-interval variations of the polarity change of the electric driving signals by using the additional analog switch (24), which selects between the voltage levels V_{S1} and V_{S2} connected to the inputs (27) and (28) of the said analog switch so that it changes the reference voltage V_C at its output (25) connected to the reference input (55) of the comparator (54) and

that the selection of the reference voltage is made according to the signal given by the sensor element (35) and synchronized with the appropriate electric driving signal for the LCD electrooptic switching element (1) so that the signal that is generated by the sensor (35) at its output (34), connected to the synchronization input (31), synchronizes the logic control circuitry (30), which through its output (32), connected to the control input (26) of the analogue switch

(24), controls the said analogue switch (24) in such a way that it selects the reference voltage V_C at its output (25), connected to the reference input (55) of the comparator (54), so that the time-interval variations of the polarity change of the electric driving signals, controlled by the comparator (54), are as small as possible.

8. The electronic circuitry for the implementation of the driving scheme of claim 1 as claimed in claims 5 and 6, characterized in that the integration of the LCD electrooptic switching element driving signals is implemented by the periodic, sufficiently frequent, transfer of the charge proportional to the LCD electrooptic switching element driving voltage, into the integrating capacitor (110) by the transfer capacitor (101) and electronic analog switches (102) and (103), where the complete transfer of the charge from the transfer capacitor (101) into the integrating capacitor (110) is provided by two transistors of the opposite polarity (115) and (116) with base leads interconnected and emmitor leads interconnected.

9. The electronic circuitry for the implementation of the driving scheme of claim 1 as claimed in claims 5 and 6, characterized in that the comparation of the integral of the LCD control signals with the reference voltage V_C and the discharging of the integrating capacitor (110) is provided by two transistors of the opposite polarity (117) and (118), which have their base leads connected to the collector leads of the other transistor, while remaining emitter leads are connected to the integrating capacitor (110) and the output signal from the circuit is provided by additional NPN transistor (119).

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
218-P06PC/99		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/SI99/00024	25/10/1999	26/10/1998

International Patent Classification (IPC) or national classification and IPC
G02F1/133

Applicant
PIRS, Janez et al.

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 7 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 6 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
25/05/2000	08.02.01

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Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/SI99/00024

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:
Description, pages:

1,4-18	as originally filed			
2,2a-2b,3,3a	as received on	11/11/2000	with letter of	06/11/2000

Claims, No.:

1-9	as received on	11/11/2000	with letter of	06/11/2000

Drawings, sheets:

1/9-9/9	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☒ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)
   see separate sheet

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-9
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-9
Industrial applicability (IA)	Yes:	Claims	1-9
	No:	Claims	

2. Citations and explanations
   see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Re Item I

1 The general description of the invention as originally filed was replaced by a new statement (page 3a: "The scope and the goal of the invention ...") that introduces novel subject-matter. In particular, the statements related to the "two polarity reversals" (page 3a) are not unambiguously derivable from the original application documents (Article 34 (2)(b) PCT).

Re Item V

2 The documents cited in the international search report will be named D1-D8.

3 The claims are unclear to such an extent (see section VIII) that only a preliminary opinion can be given as to whether the application meets the requirements of Articles 33(2) and (3) PCT and Rule 13.1 PCT.

3.1 It appears that claims 1 and 2 relate to a method of DC balancing a liquid crystal element (cf. the penultimate paragraph on page 4). Having regard to this aspect the following is noted.

3.2 The document D2 (IBM Technical Disclosure Bulletin) discloses a method and a corresponding circuit for DC balancing a liquid crystal element wherein the potential difference between the two electrodes of a liquid crystal element is integrated ("A1", "A2", "low pass filter A3") and used to "automatically adjust it nearly to null" (see also last sentence on page 163).

3.3 The documents D1 (US 4 205 311) and D3 (English language abstract of JP 8 082 785) both disclose a method and circuit for DC balancing a liquid crystal element wherein the voltage at one of two electrodes of a liquid crystal element is integrated and applied to the second electrode so as to Dependent claim-balance the liquid crystal element. In particular, in the circuit of document D1 (see figure 9) the driving signal supplied to the liquid crystal element 1 by the impedance converter 11 adapts its value and its polarity so as to minimize the DC component applied to the liquid crystal element.

3.4 Hence, the problem of DC balancing of a liquid crystal element is solved in the prior art in a manner similar to the method of claims 1 and 2. Insofar as these claims can be understood, they thus seem to lack an inventive step (Article 33(3) PCT).

3.5 Moreover, it seems that the circuits of claims 3-9 solve the same problem in a similar way and differ from the circuits of the cited prior art merely in the details of the implementation. However, the use of standard circuit parts for their intended purpose is considered to fall within the competence of a skilled person (Article 33(3) PCT). Moreover, the independent claims 3, 5, and 6 are considered not to be linked by a single general inventive concept (Rule 13.1 PCT).

3.6 Having regard to another aspect of the present application (last paragraph on page 4), it is noted that the document D7 teaches to short-circuit the electrodes of a liquid crystal elements during every change of polarity of the driving signals in order to reduce energy consumption.

Re Item VII

4 The features of claims 1 and 2 are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

Re Item VIII

5 The application does not meet the criteria of Article 6 PCT for the following reasons.

5.1 The three independent claims 3, 5, and 6 directed at electronic circuitry overlap in scope and comprise a plurality of mutually exclusive features (Rule 6.4 (a) PCT). Hence, the set of claims is not concise (PCT Guidelines III, 5.1) and it is not clear which features are essential features of the invention (PCT Guidelines III, 4.4).

5.1.1 In order to overcome this objection, it would appear appropriate to file an amended set of claims defining the relevant subject-matter in terms of a **single** independent claim in each category followed by dependent claims covering features which are merely optional (Rule 6.4 PCT).

5.2 The claims 1 and 2 seem to relate to a method of driving a liquid crystal element. However, no method steps can be identified in these claims. Furthermore, it is not clear which features or results to be achieved are intended to be defined in lines 9-11 of claim 1 and in lines 17-21 of claim 2.

5.3 It would appear that the newly filed claim 2 is vaguely related to the aspect of the drive scheme described on page 9, second paragraph. According to that section of the description, the reference voltage level V_{c1} is changed "according to the signal generated by the sensor 35" such that "the time-intervals of the polarity changes of the electric driving signals are as uniform as possible". However, no features corresponding to the sensor signal can be identified. It would therefore also appear that this claim does not meet the requirements of Article 34 (2)(b) PCT.

5.4 The meaning of the reference to a feature is not clear without an antecedent definition of the feature. However, such unclear references are used throughout the set of claims (see, for example, claim 3: "the electric driving signals", "the electrodes", "the difference inputs", "the differential amplifier" etc.), rendering obscure which features the claims comprise. This objection applies to the method claims 1 and 2 in a similar manner.

5.4.1 In order to overcome this objection, it seems necessary to clearly define which circuit elements the circuit comprises and then to define the interrelationship of those elements.

5.5 Expressions or terms without well defined meaning are used throughout the set of claims. For example, the meaning of expressions like "the first even change of polarity" (claim 2, line 17) or "optimum dynamics of the electrooptic response" (claim 1, lines 4-5) is obscure.

5.6 Throughout the set of claims, several structural features are can be distinguished from each other solely by their reference signs (for example, claim 3, "the electrodes (2) and (3) ..."), which is confusing and does not meet the requirements of Rule 6.2 (a) PCT. The use of similar or identical wording to refer to different structural features should therefore be avoided.

5.7 The reference to the spirit of the invention (page 18, last line) implies that the subject-matter for which protection is sought may be different to that defined by the claims, thereby resulting in a further lack of clarity (Article 6 PCT) when used to interpret them (see also the PCT Guidelines, III-4.3a).

which significantly reduces the consumption of the electric energy in such a way that the automatic turn-off is no longer needed (Gunz, Ghisleni, EP 550,384, US 5,315,099). While the former patent application does not represent any significant novelty and is not solving the problem of the electric power consumption satisfactorily, the later solution is technically very important. Its basic deficiency lies in the fact that it cannot be used with the frequencies above 0.3Hz when the transient phenomena, which accompany the low frequency driving, become too apparent and distract the user (noticeable time variations of the light attenuation). Since it is not possible to synchronize the driving signals at such low frequencies with the time periods when the LCD electrooptical element has to be in the closed state (for example: welding), the above described LCD light shutter and the electric driving technique cannot provide a complete compensation of the DC component of the electric driving voltage, resulting in the reduced life time of the LCD electrooptic switching elements. The authors of the patent application EP 550,384 diminish this problem by changing the phase of the electric driving signals with every activation of the LCD electrooptical element, which only reduces the consequences and does not represent a reliable solution of the problem. Another known solution proposed by Fergason, US 5,347,383, US 5,252,817 uses the dual-frequency driving, the frequency being dependent on the optical state that the electrooptical switching element currently occupies. This allows for the quick changing of the polarity of the electric driving signals when the filter is in the optically open state (reduced flickering of the filter) and slow changing when the filter is optically closed and the flickering is not so pronounced. The consumption of the electric energy is therefore reduced, however only in one optical state, which does not represent the optimal solution of the problem of the consumption of the electric energy.

- The increased switching speed of the LCD electrooptic switching elements is generally achieved by using the high amplitude of the electric driving signals (Heimeier, US 3,575,491, US 3,731,986). The optimal results can be achieved by using the appropriate time dependence of the amplitude of the electric driving signals for the LCD electrooptic switching elements (Fig.1) as disclosed in the patent application (Toth, EP 0,157,744). According to this technical solution the LCD electrooptic switching element is already in the "open state", driven with the electric signals, the amplitude of which is smaller than the voltage threshold required for the electrooptical switching. The switching speed to the closed state of the LCD electrooptical-switching element is therefore significantly increased. The amplitude of the electric driving signals is very high immediately after the activation and decreases to the voltage level, which is required to maintain the required optical light attenuation.

The scope and the goal of the invention is the electronic driving scheme as well as the adequate electronic circuitry for the driving of the LCD electrooptic switching elements with the following characteristics:

- Long-term autonomous operation, independent of the outside electric energy sources
- Optimization of the electric driving signals in the sense of the fast switching dynamics
- Optimization of the electric driving signals in the sense of maximizing the life time of the LCD electrooptic switching elements
- Optimization of the electric driving signals in the sense of minimization of the electric power consumption

According to the invention the problem is solved using independent patent claims.

Following is a detailed description of the preferred embodiments of the invention further described by means of the annexed drawings:

Fig. 1. - Multilevel time dependence of the amplitude of the electric driving signals allowing for the maximum switching speed

Fig. 2a - Symmetric, square-wave, periodic, alternating electric driving signals for the LCD electrooptic-switching element

Fig. 2b - Irregular electric driving signals for the LCD electrooptic switching element, having the long-term DC component equal to zero

Fig. 3. - Block diagram of the electronic circuitry, allowing for the compensation of the long-term DC component of the electric driving signals based on the complete time integral of the difference of the driving electric potentials across the LCD electrooptic switching element

Fig. 4. - Time-dependence of the most essential electric signals of the electronic circuitry in the Fig. 3.

Fig. 5. - Block diagram of the electronic circuitry, allowing for the compensation of the long-term DC component of the electric driving signals, based on the "partial" time integral of the difference of the driving electric potentials across the LCD electrooptic switching element

Fig. 6. - Time-dependence of the most essential electric signals of the electronic circuitry in the Fig. 5.

Patent claims

1. The driving scheme for the LCD electrooptic elements with alternating square-wave electric signals, the amplitude of which can vary between the different electric levels according to the actual status so that the optimum dynamics of the electrooptic response is assured, characterized in that the changing of the polarity of the electric driving signals is controlled by the integrator, which integrates the potential differences between the electrodes of the LCD electrooptic switching element so that it keeps the value of the time integral of the driving voltages within the predetermined interval allowing for the complete compensation of the long-term DC component of the electric driving field for the LCD electrooptic switching element and that can be optionally complemented with the driving scheme, allowing for the short, spontaneous discharging of the capacitance of the LCD electrooptic switching element at every reversal of the polarity of the driving signals.

2. The driving scheme for the LCD electrooptic switching elements characterized in that with every change of the polarity of the driving signals, both electrodes of the LCD electrooptic switching element are connected to the same electric potential for the time, which is significantly shorter than the electrooptical response of the LCD electrooptic switching element, but longer than the time needed to remove the electric charge from the electrodes of the LCD electrooptic switching element, allowing for the spontaneous discharge of the capacitor represented by the electric capacitance of the LCD electrooptic switching element.

3. The electronic circuitry for the driving of the LCD electrooptic switching element (1) with alternating square-wave driving signals, the amplitude of which can vary between the different electric levels according to the actual status so that the optimum dynamics of the electrooptic response is assured, characterized in that the electric driving signals on the electrodes (2) and (3) of the LCD electrooptic switching element (1) are connected to the difference inputs (4) and (5) of the differential amplifier (6), the output signal (7) of which is connected to the input (8) of the integrator (9) and

   that the output signal (10) of the integrator (9) is connected to the comparator inputs (12) and (22) of the comparators (13) and (20), the reference inputs (11) and (21) of which are connected to the electric potentials V_{C2} and V_{C1} respectively, while the signals, generated at the outputs (14) and (23) of the comparators (13) and (20), enable the

control over the logic control signals for the LCD electrooptic switching element (1) via the "set/reset" inputs (16) and (15) of the control "flip/flop" circuit (17) so that the electric driving signals for each of the electrodes of the LCD electrooptic switching element (1), generated at its outputs (18) and (19) are phase shifted by 180° (Q/ $\bar{Q}$) and

that these logic control signals are connected to the inputs (39) and (40) of the voltage translator (36), which transforms them into the driving signals for the LCD electrooptic switching element (1) at its outputs (37) and (38) connected to the control electrodes (2) and (3) of the LCD electrooptic switching element (1), the amplitude of these driving signals being determined by the voltage level V_{LCD}, which is connected to the control input (41) of the voltage translator (36) and

that the said electronic driving circuitry can be optionally complemented with the electronic circuitry for the reduction of the time-interval variations of the polarity change of the electric driving signals for the LCD electrooptic switching element (1) and with the electronic circuitry for the generation of the time/phase delay of the electric driving signals for the LCD electrooptic switching element (1)

4. The electronic circuitry for the driving of the LCD electrooptic switching element with alternating square-wave electric driving signals, the amplitude of which can vary between the different electric levels according to the actual status so that the optimum dynamics of the electrooptic response is assured, according to the claim 3, characterized in that it reduces the time-interval variations of the polarity change of the electric driving signals by means of using the additional analog switch (24) that selects between the voltage levels V_{S1} and V_{S2}, connected to the inputs (27) and (28) of the said analogue switch so that it changes the reference voltage V_{C1} at its output (25), connected to the reference input (21) of the comparator (20) and

that the selection of the reference voltage is made synchronously with the adequately selected driving signal for the LCD electrooptic switching element (1) and according to the signal given by the sensor element (35) so that the signal, which is generated by the sensor (35) at its output (34), connected to the synchronization input (31), synchronizes the logic control circuitry (30) in such a way that the logic signal at its output (32), connected to the control input (26) of the analogue switch (24), controls the said analogue switch in such a way that it selects the voltage level V_{C1} at its output (25), connected to the reference input (21) of the comparator (20), so that the time-interval

variations of the polarity change of the electric driving signals, controlled by the comparator (20), are as small as possible.

5. The electronic circuitry for the driving of the LCD electrooptic switching element with alternating square-wave electric signals, the amplitude of which can vary between different electric voltage levels according to the actual status so that the optimum dynamics of the electrooptic response is assured, characterized in that the electric driving signals on the electrodes (2) and (3) of the LCD electrooptic switching element (1) are connected to the inputs (49) and (50) of the analogue switch (48), the output signal (51) of which is connected to the input (8) of the integrator (9) and

that the output signal (10) of the integrator (9) is connected to the comparator input (56) of the comparator (54), the reference input (55) of which is connected to the electric potential V_C, while the signal generated at the output (57) of the comparator (54) enables the control of the logic driving signals for the LCD electrooptic switching element (1) via the input (16) of the control "flip/flop" switching circuit (17) so that the electric driving signals for each of the electrodes of the LCD electrooptic switching element (1), generated at its outputs (18) and (19) are phase shifted for 180° (Q/ $\bar{Q}$) and that at the same time the output (19) of the switching electronic circuitry (17) is connected to the control input (58) of the analog switch (48), selecting one of the driving electric voltages of the LCD electrooptic switching element (1) and that the output (57) of the comparator (54), is connected to the select input (61) of the analog switch (60), so that with every change of the polarity of the electric driving field between the electrodes of the LCD electrooptic switching element (1) the said analogue switch (60) switches for a short time its output (53), connected to the input (52) of the of the integrator (9), from its electrically floating input (62) to the adequately chosen constant electric potential, connected to its input (63), which results in resetting the integrator (9) to the initial state and

that the logic driving signals at the outputs (18) and (19) of the switching logic circuitry (17) are connected to the inputs (39) and (40) of the voltage translator (36) that transforms them on its outputs (37) and (38), connected to the electrodes (2) and (3) of the LCD electrooptic switching element (1), into the electric driving signals for the said LCD electrooptic switching element (1), the amplitude of which being determined by the electric voltage V_{LCD}, connected to the control input (41) of the voltage translator (36) and

that this electronic circuitry can be optionally complemented with the electronic circuitry for the reduction of the time-interval variations of the polarity-change of the electric driving signals for the LCD electrooptic switching element (1) and with the electronic circuitry for the generation of the time/phase delay of the electric driving signals.

6. The electronic circuitry for the driving of the LCD electrooptic switching element with alternating square-wave electric signals, the amplitude of which can vary between different electric voltage levels according to the actual status so that the optimum dynamics of the electrooptic response is assured, characterized in that the voltage output (43) of the analogue switch (42) which is apart from being connected to the input (41) of the voltage translator (36), connected also directly to the input (8) of the integrator (9) and

that the output signal (10) of the integrator (9) is connected to the comparator input (56) of the comparator (54), the reference input (55) of which is connected to the electric potential V_C, while the signal generated at the output (57) of the comparator (54) enables the control of the logic driving signals for the LCD electrooptic switching element (1) via the input (16) of the control "flip/flop" switching circuit (17) so that the driving signals for each of the electrodes of the LCD electrooptic switching element (1), generated at its outputs (18) and (19) are phase shifted for 180° (Q/ $\bar{Q}$) and

that the output (57) of the comparator (54) is connected to the select input (61) of the analogue switch (60) so that with every change of the polarity of the electric driving field between the electrodes of the LCD electrooptic switching element (1) the said analogue switch (60) switches for a short time its output (53), which is connected to input (52) of integrator (10), from its electrically floating input (62) to the adequately chosen constant electric potential V_p, connected to its input (63), which results in resetting the integrator (9) to the initial state and

that the logic driving signals at the outputs (18) and (19) of the switching logic circuitry (17) are connected to the inputs (39) and (40) of the voltage translator (36) that transforms them on its outputs (37) and (38), connected to the electrodes (2) and (3) of the LCD electrooptic switching element (1), into the electric driving signals for the said LCD electrooptic switching element (1), the amplitude of which being determined by the electric voltage V_{LCD}, connected to the control input (41) of the voltage translator (36) and

that this electronic circuitry can be optionally complemented with the electronic circuitry for the reduction of the time-interval variations of the polarity-change of the electric driving signals for the LCD electrooptic switching element (1) and with the electronic circuitry for the generation of the time/phase delay of the electric driving signals.

7. The electronic circuitry for the driving of the LCD electrooptic switching element with alternating square-wave electric driving signals, the amplitude of which can vary between the different electric levels according to the actual status of the said LCD electrooptic switching element, so that the optimum dynamics of the electrooptic response is assured, according to the claim 5 and claim 6, characterized in that it reduces the time-interval variations of the polarity change of the electric driving signals by using the additional analog switch (24), which selects between the voltage levels V_{S1} and V_{S2} connected to the inputs (27) and (28) of the said analog switch so that it changes the reference voltage V_C at its output (25) connected to the reference input (55) of the comparator (54) and

that the selection of the reference voltage is made according to the signal given by the sensor element (35) and synchronized with the appropriate electric driving signal for the LCD electrooptic switching element (1) so that the signal that is generated by the sensor (35) at its output (34), connected to the synchronization input (31), synchronizes the logic control circuitry (30), which through its output (32), connected to the control input (26) of the analogue switch (24), controls the said analogue switch (24) in such a way that it selects the reference voltage V_C at its output (25), connected to the reference input (55) of the comparator (54), so that the time-interval variations of the polarity change of the electric driving signals, controlled by the comparator (54), are as small as possible.

8. The electronic circuitry for the driving of the LCD electrooptic switching element with alternating square-wave electric driving signals, the amplitude of which can vary between the different electric levels according to the actual status, so that the optimum dynamics of the electrooptic response is assured, according to claims 3, 5, and 6, characterized in that the logic driving signal for the LCD electrooptic switching element (1), which is generated at the output (18) of the "flip/flop" switching circuitry (17), instead of being connected directly to the input (39) of the voltage translator (36), is connected to the input (65) of the delay circuitry (64), the output (66) of which, is connected to the input (39) of the voltage translator (36), so that the logic driving signal is delayed for the

time, which is significantly shorter than the dynamics of the electrooptical response of the LCD electrooptic switching element (1) but longer than the time needed to remove the electric charge from the electrodes of the LCD electrooptic switching element (1).

9. The electronic circuitry for the driving of the LCD electrooptic switching element with alternating square-wave electric driving signals, the amplitude of which can vary between different electric voltage levels according to the actual status of the said LCD electrooptic switching element so that the optimum dynamics of the electrooptic response is assured, characterized in that the integration of the LCD electrooptic switching element driving signals is implemented by the periodic, sufficiently frequent, transfer of the charge proportional to the LCD electrooptic switching element driving voltage, into the integrating capacitor (110) by the transfer capacitor (101) and electronic analog switches (102) and (103), where the complete transfer of the charge from the transfer capacitor (101) into the integrating capacitor (110) is provided by two transistors of the opposite polarity (115) and (116) with base leads interconnected and emmiter leads interconnected.

10. The electronic circuitry for the driving of the LCD electrooptic switching element with alternating square-wave electric driving signals, the amplitude of which can vary between different electric voltage levels according to the actual status of the said LCD electrooptic switching element so that the optimum dynamics of the electrooptic response is assured, characterized in that the comparation of the integral of the LCD control signals with the reference voltage V_C and the discharging of the integrating capacitor (110) is provided by two transistors of the opposite polarity (117) and (118), which have their base leads connected to the collector leads of the other transistor, while remaining emitter leads are connected to the integrating capacitor (110) and the output signal from the circuit is provided by additional NPN transistor (119).

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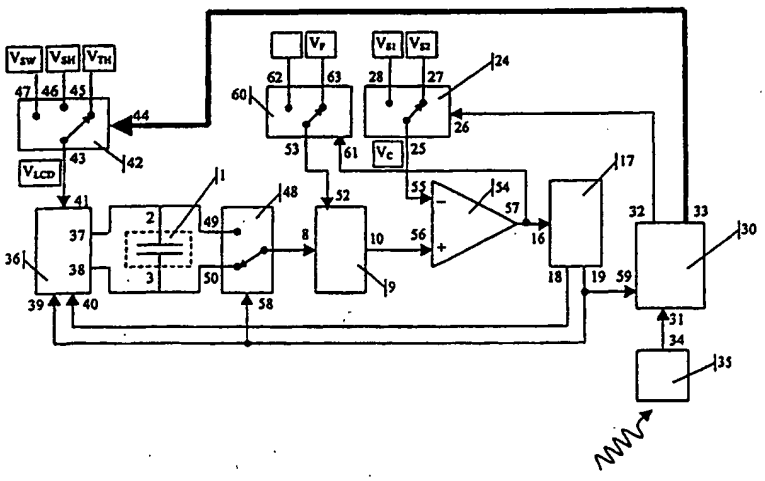

(57) Abstract

The invention relates to the problem of the driving of the LCD electrooptic–switching element (1) with alternating, square–wave electric signals, the amplitude of which can vary between different voltage levels in correspondence with the actual functioning state of the LCD electrooptic–switching element. The polarity changes of the electric driving signals is controlled by the integrator (9), integrating the difference of the electric potentials on the driving electrodes (2, 3) of the LCD electrooptic switching element, in such a way that the value of the time integral of the driving electric field is always kept within a selected interval. Besides this the time dependence of the electric driving signals can be optionally modified so that with every change of the polarity of the electric driving signals, the potentials on both driving electrodes get the same value for a time, which is significantly shorter than the switching time of the LCD electrooptic switching element.

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Driving scheme and electronic circuitry for the LCD electrooptical switching element

The present invention relates to the driving method for the LCD electrooptic-switching element and the manufacturing of the automatic electronic driving circuitry for the LCD electrooptic-switching element, which is among other applications especially interesting as the basic active element in the various optical systems and automated protection devices such as automatic welding helmet.

The present invention relates to the driving method and the manufacturing of the automatic electronic driving circuitry for the LCD electrooptic switching element, which allows for the:

- long-term autonomous functioning independent of the external power sources
- optimizing of the electric driving signals in the sense of the fast electrooptical switching dynamics, long life time of the LCD electrooptic switching elements and the minimal use of energy (several years without changing the batteries):
  - multilevel electronic driving of the LCD electrooptic switching elements
  - minimal consumption of the electric energy for the driving of the LCD electrooptic switching elements
  - compensation of the DC component of the electric driving signals for the LCD electrooptic switching elements

So far several technical solutions and applications of the electrooptical switching elements were made. The solutions are disclosed in the following patents: the use of the double "twist-nematic" LCD cell (Gurtler, US 3,890,628); one TN and one "Guest-host" LCD cell (Morizama, US 3,967,881); the use of the LCD or the ceramic active element (Budminger, FR 2,293,188); the LCD with passive and active cell (Hornell, EP 0,005,417); the optical switch and the variable polarizer (Fergason, US 5,074,647)

There are also a number of partial solutions of said technical problem. All of the modern technical solutions incorporate an autonomous battery power supply supported by the semiconductor solar cell which significantly increases the life time of the battery power supply (Pfanzelt, DE 3,017,242: Bruhin, EP 0,09,514: Tyers, GB 2,138,590: Bruhin CH 671,485: Stanelli, EP 0,331,861):

- minimization of the electric energy consumption and the optimization of the electric driving signal is guaranteed either by the use of the automatic turn-off of the protective automatic LCD welding filter and manual turn-on just prior to the welding (Fergason, US 5,377,032), or with the low-frequency driving of the LCD electrooptic switching elements

which significantly reduces the consumption of the electric energy in such a way that the automatic turn-off is no longer needed (Gunz, Ghisleni, EP 550,384, US 5,315,099). While the former patent application does not represent any significant novelty and is not solving the problem of the electric power consumption satisfactorily, the later solution is technically very important. Its basic deficiency lies in the fact that it cannot be used with the frequencies above 0.3Hz when the transient phenomena, which accompany the low frequency driving, become too apparent and distract the user (noticeable time variations of the light attenuation). Since it is not possible to synchronize the driving signals at such low frequencies with the time periods when the LCD electrooptical element has to be in the closed state (for example: welding), the above described LCD light shutter and the electric driving technique cannot provide a complete compensation of the DC component of the electric driving voltage, resulting in the reduced life time of the LCD electrooptic switching elements. The authors of the patent application EP 550,384 diminish this problem by changing the phase of the electric driving signals with every activation of the LCD electrooptical element, which only reduces the consequences and does not represent a reliable solution of the problem. Another known solution proposed by Fergason, US 5,347,383, US 5,252,817 uses the dual-frequency driving, the frequency being dependent on the optical state that the electrooptical switching element currently occupies. This allows for the quick changing of the polarity of the electric driving signals when the filter is in the optically open state (reduced flickering of the filter) and slow changing when the filter is optically closed and the flickering is not so pronounced. The consumption of the electric energy is therefore reduced, however only in one optical state, which does not represent the optimal solution of the problem of the consumption of the electric energy.

- The increased switching speed of the LCD electrooptic switching elements is generally achieved by using the high amplitude of the electric driving signals (Heimeier, US 3,575,491, US 3,731,986). The optimal results can be achieved by using the appropriate time dependence of the amplitude of the electric driving signals for the LCD electrooptic switching elements (Fig.1) as disclosed in the patent application (Toth, EP 0,157,744). According to this technical solution the LCD electrooptic switching element is already in the "open state", driven with the electric signals, the amplitude of which is smaller than the voltage threshold required for the electrooptical switching. The switching speed to the closed state of the LCD electrooptical-switching element is therefore significantly increased. The amplitude of the electric driving signals is very high immediately after the activation and decreases to the voltage level, which is required to maintain the required optical light attenuation.

The scope and the goal of the invention is the electronic driving scheme as well as the adequate electronic circuitry for the driving of the LCD electrooptic switching elements with the following characteristics:

- Long-term autonomous operation, independent of the outside electric energy sources
- Optimization of the electric driving signals in the sense of the fast switching dynamics
- Optimization of the electric driving signals in the sense of maximizing the life time of the LCD electrooptic switching elements
- Optimization of the electric driving signals in the sense of minimization of the electric power consumption

According to the invention the problem is solved using independent patent claims.

Following is a detailed description of the preferred embodiments of the invention further described by means of the annexed drawings:

Fig. 1. - Multilevel time dependence of the amplitude of the electric driving signals allowing for the maximum switching speed

Fig. 2a - Symmetric, square-wave, periodic, alternating electric driving signals for the LCD electrooptic-switching element

Fig. 2b - Irregular electric driving signals for the LCD electrooptic switching element, having the long-term DC component equal to zero

Fig. 3. - Block diagram of the electronic circuitry, allowing for the compensation of the long-term DC component of the electric driving signals based on the complete time integral of the difference of the driving electric potentials across the LCD electrooptic switching element

Fig. 4. - Time-dependence of the most essential electric signals of the electronic circuitry in the Fig. 3.

Fig. 5. - Block diagram of the electronic circuitry, allowing for the compensation of the long-term DC component of the electric driving signals, based on the "partial" time integral of the difference of the driving electric potentials across the LCD electrooptic switching element

Fig. 6. - Time-dependence of the most essential electric signals of the electronic circuitry in the Fig. 5.

Fig. 7. - Time-dependence of the electric driving signals, allowing for the reduction of the electric energy consumption, based on the additional phase shift Fig. 8. - Block diagram of the electronic circuitry for the additional relative time/phase delay between the two electric driving signals for the LCD electrooptic switching element

Fig.9. - Block diagram of the simplified electronic circuitry, allowing for the compensation of the long-term DC component of the electric driving signals for the LCD electrooptic switching element based on the "partial" time integral of the difference of the driving voltage across the LCD electrooptic switching element

Fig.10.- Block diagram of the integrator and the comparator, which uses an additional capacitor and two toggle switches for the transfer of the charge to the integrating capacitor to reduce the input current to the integrator instead of using the large value resistor at the input to the integrator

Fig. 11- The implementation of the integrator circuit following the block diagram from Fig. 10, which assures the complete transfer of the charge from the transfer capacitor into the integrating capacitor with the minimal power consumption.

Fig. 12. - The implementation of the comparator circuit, which also discharges the integrating capacitor and has minimal electric power consumption; it is interconnected with the integrator circuit from Fig. 11 as shown in Fig. 10.

The present invention provides the electric driving scheme for the LCD electrooptic switching elements using alternate square-wave electric signals (Fig. 2b), the changing of the polarity of which is controlled by the integrator, which integrates the difference of the voltages on the driving electrodes of the LCD electrooptic switching elements in such a way that it preserves the value of the time integral of the difference of the electric driving signals within the predetermined interval.

This invention is further characterized in that it can be optionally upgraded by using the electric driving scheme for the LCD electrooptic switching elements, which with every change of the polarity of the electric driving signals, connects both electrodes of the LCD electrooptic switching element to the same electric potential for a time, which is significantly shorter than the electrooptical response of the LCD electrooptic switching element, but longer than the time needed for the spontaneous discharge of the capacitor represented by the electric capacitance of the LCD electrooptic switching element. Approximately 50% reduction in the electric power consumption is achieved this way.

Another aspect of the invention is that it, unlike other existing technical solutions, allows without any limitations the use of the optimal time dependence of the amplitude of the electric driving signals (maximal speed of the electrooptical response), as well as very slow changes of the polarity of the electric driving signals with specific time dependence (minimal consumption of the electric energy) while assuring the complete compensation of the DC component of the electric driving signals for the LCD electrooptic switching element (life time,...):

- It allows for the use of the conventional driving technique, based on the time dependence of the amplitude of the electric driving signals (Fig.1.) resulting in maximal speed of the electrooptical response of the LCD electrooptic switching element. The basic idea is that the electric driving circuitry provides "a weak electric driving voltage" ($V_{LCD}=V_{TH}$) between the driving electrodes of the LCD electrooptic switching element (on the "switching threshold" V_{TH} for the LCD electrooptic switching element) even during the time before t_o, when the command for the optical switching occurs (for example: welding) and the LCD light shutter is still in the open state (transmitting light). In this situation the response of the LCD light shutter to the driving signals is significantly faster. If at the same time, at the beginning of the switching into the closed state ($t = t_o$), the amplitude of the driving electric field raises significantly above the switching threshold V_{TH} for the driving of the LCD electrooptic switching element ($V_{LCD}=V_{SW}>>V_{TH}$), a very fast switching dynamics can be obtained. During the closed state (time–interval t_w), after an adequate time ($t = t_{sw}$) has elapsed, which is determined by the switching speed of the LCD electrooptic switching element, the amplitude of the electrical driving signal can be reduced to the value ($V_{LCD}= V_{SH}$), that maintains the required light attenuation (for example: "shade" during the welding).
- It provides the complete compensation of the long-term DC component of the electric driving field for the LCD electrooptic-switching element. The driving of the LCD electrooptic-switching element with the DC voltage is basically unacceptable because of the electro-chemical phenomena, which tend to reduce its lifetime. At the same time, due to the presence of ions in the liquid crystal and in the orienting layer, the electric charge screening of the electrical driving field occurs, resulting in an inadequate performance. Contrary to the other technical solution, which as a rule use symmetrical, square-wave, periodical, alternating electric driving signals (fig 2a), the DC component of the electric driving field of which equals zero, the present invention is based on the use of a square-wave, from the frequency point of view irregular driving signals having the long-term DC component (several 10 seconds) equal to zero (Fig. 2b). Since the proposed solution is

based on the time integration of the electric potential difference of the driving signals and the appropriate time dependence of the changing of the polarity of the said driving signals, it provides the complete compensation of the long-term DC component even when using the electric driving signals with very slow changing of the polarity so that they cannot possibly be synchronized with the signals controlling the optical switching of the LCD electrooptic switching element.

- It allows for the minimal consumption of the electric power needed for the driving of the LCD electrooptic switching element based on the above mentioned very slow changing of the polarity of the electric driving signals, as well as their special time dependence. The fact is that the driving of the LCD electrooptic switching element is in practice for the sake of simplicity realized with two alternate, essentially identical electric driving signals, phase shifted by 180°, for each of the driving electrodes. So the electric field, generated between the said electrodes, has a constant amplitude and the periodically varying polarity (Fig. 2a). The inadequacy of such a driving method is above all the fact that the electronic driving circuitry, with every change of the polarity of the electric driving field in the LCD electrooptic switching element, first has to remove the entire electric charge from the capacitor, represented by the electric capacitance of the LCD electrooptic switching element and then charge it in the opposite sense. Although it is actually dealing with the "capacitive current", it actually results in the direct consumption of the electric energy. This invention is characterized in that it solves this problem in such way that with every change of the polarity of the electric driving signals both electrodes of the LCD electrooptic switching element are connected to the same electric potential for the time, which is significantly shorter than the electrooptical response of the LCD electrooptic switching element, but noticeably longer than the time needed to remove the electric charge. This allows for the spontaneous discharge of the capacitor represented by the electric capacitance of the LCD electrooptic switching element, which leads to the reduction of the consumption of the electric power by approximately 50%. According to the invention the above described LCD driving concept is accomplished by the means, providing the additional small relative time/phase shift between both electric driving signals for the LCD electrooptic switching element (slightly away from the ideal 180° phase shift). The time dependence of the electric driving signals for the LCD electrooptic switching element with the said additional phase shift has not been described so far, which is evident from all the manufacturers manuals for the use of the integrated circuits, designed for the driving of the LCD displays, as well as the professional publications on the driving schemes.

The circuit described is unique by the implementation of the integrator input circuit, which contrary to the classical integrators, where the integrating capacitor is charged by a continuos current, proportional to the input voltage, here the charge proportional to the input voltage is periodically, with a sufficiently short period, transferred into the integrating capacitor. Using this technique the average input current to the integrator is reduced without the use of a large value input resistors, which are difficult to be realized using microelectronic design. Since the average input current to the integrator is small, the current consumption of the power supply for the LCD electrooptic-switching element is also small.

The circuit described is characterized also by its implementation of the integrator circuit, which assures the complete transfer of the charge from the charge transfer capacitor into the integrating capacitor and, at the same time, has minimal power consumption.

The circuit described is additionally characterized by its implementation of the comparator circuit, which is also used to discharge the integrating capacitor, when the voltage across its terminals reaches the predefined value V_c and has minimal power consumption.

The electronic realization of the above described scheme for the electric driving signals using the additional phase shift, which results in the significant reduction of the electric power consumption, is by itself very simple and does not need any further description. The long-term compensation of the DC voltage component of the driving signals for the LCD electrooptic switching element based on the time integration of the driving signals, is however far more complex and is therefore described in three examples of the preferred embodiment:

Preferred embodiment 1:

The block diagram of the electronic driving circuitry for the driving of the LCD electrooptic switching element 1, providing the long-term compensation of the DC component of the electric driving field, is illustrated in the Fig. 3., while the most relevant electric signals in the said circuitry are shown in the Fig. 4.:

The basic principle of the operation of the said electric circuitry is based on the measuring of the time integral of the difference of the electric driving signals on the electrodes of the LCD electrooptic switching element 1 and the corresponding time changes of the polarity in such way that the integral of the difference of the said driving signals remains all the time within

the allowed interval (V_{C1} to V_{C2}). This results in the complete compensation of the long-term DC voltage component of the electric driving signals for the LCD electrooptic-switching element 1. Therefore the driving signals (V_{LCD1} and V_{LCD2} in Fig.4.) on the electrodes 2 and 3 of the LCD electrooptic switching element 1 are connected to the difference inputs 4 and 5 of the differential amplifier 6, while the output signal 7, which is proportional to the electric driving field for the LCD electrooptic element 1, is connected to the input 8 of the integrator 9. The output signal 10 (Int in Fig.4.) of the integrator 9 is connected to the comparator inputs 12 and 22 of the comparators 13 and 20. Since the reference input 11 of the comparator 13 is connected to the electrical potential ($V=V_{C2}$) and the reference input 21 is connected to the reference voltage level ($V=V_{C1}$), the signals, generated by the comparators 13 and 20 at their outputs 14 and 23 (C_1 and C_2 in Fig.4.), enable the control over the electric driving signals (V_{LCD1} and V_{LCD2} in Fig.4.) for the LCD electrooptic switching element 1 in such way that the time integral of the difference of the said DC voltage component of the electric driving field never exceeds the allowed value. The time dependence of the electric driving signals for the LCD electrooptic switching element 1 is defined by the comparators 13 and 20, their outputs 14 and 23 being connected via the "set/reset" inputs 16 and 15 of the logic "flip/flop" circuitry 17. Under the control of the said driving signals, the "flip/flop" circuitry 17 generates the driving signals (FF_Q in Fig.4. and FF $\bar{Q}$) at its outputs 18 and 19 for each of the electrodes of the LCD electrooptic switching element 1 respectively, so that they are phase shifted by 180° (Q/ $\bar{Q}$). The logic control signals at the outputs 18 and 19 of the "flip/flop" circuitry 17 are connected to the inputs 39 and 40 of the voltage translator 36 which transforms them into the driving signals for the LCD electrooptic switching element 1 with the adequately selected amplitude of the said driving signals at its outputs 37 and 38 connected to the control electrodes 2 and 3 of the LCD electrooptic switching element 1.

The time dependence of the amplitude of the electric driving signals for the LCD electrooptic switching element 1, providing for the maximum speed of the activation of the said switching element 1, can be optionally implemented in the above described electric driving scheme by using the analogue switch 42, controlled by the logic circuitry 30, which is in turn controlled by the sensor 35 so that it corresponds to the time dependence presented in the figure 1. This is achieved in such way that the control electrical impulse (Sig in Fig.4), which is generated by the sensor 35 at its output 34, connected to the input 31, activates the logic circuitry 30. The said logic circuitry via the outputs 33 of the control bus, connected to the control inputs 44 of the analogue switch 42, selects between the voltages (V_{SW}, V_{SH}, V_{TH}), which are connected to the inputs 45, 46, 47 of the analogue switch 42. The selected voltage V_{LCD} at the output 43 is connected to the driving input 41 of the voltage translator 37.

The voltage translator changes the amplitude of the logic signals which are connected to the inputs 39 and 40 and transforms them into the driving signals for the LCD electrooptic switching element 1 with the amplitude equal to the voltage on its control input 41 So the amplitude of the electric driving signals on the control electrodes 2 and 3 of the LCD electrooptic switching element 1 can be varied within the required time sequence (Fig.1.) in accordance with the signal of the sensor 35 (Sig in Fig.4.) marking the period of the activation of the LCD electrooptic switching element 1, allowing for the maximum switching speed of the LCD electrooptic switching element 1.

The above described driving scheme for the driving of the LCD electrooptic switching element 1, due to large differences in the amplitudes of the driving signals on the electrodes 2 and 3 of the LCD electrooptic switching element 1, can cause significant differences in duration times for different electric voltage levels with the said electric driving signals. Therefore it is useful to optionally change the reference voltage level V_{C1} on the input 21 of the comparator 20 according to the signal generated by the sensor 35 at its output 34, which marks the activation period of the switching element in such a way that the time-intervals of the polarity change of the electric driving signals are as uniform as possible. The appropriate selection of the reference voltage V_{C1} on the input 21 of the comparator 20 is provided by the logic control circuitry 30, which in accordance with the signal generated by the sensor 35 on its output 34 connected to the input 31 of the said control circuitry 30. The output 34 of the circuitry 30 connected to the control input 26 of the analogue switch 24, controls the said analogue switch synchronously with the signals, marking the time period of the activation of the LCD switching element (for example: welding) so that it selects between the voltage levels V_{S1} and V_{S2}, connected to its inputs 27 and 28. The selected voltage appearing at its output 25, connected to the reference input 21 of the comparator 20 (V_{COMP} in Fig.4.), determines the duration times for different electric driving voltage levels and the time intervals of the electric driving signals polarity change.

Preferred embodiment 2:

The above described realization of the regulation of the electric driving signals, based on the time integration of the driving voltage between the electrodes of the LCD electrooptic switching element 1, is certainly not the only possible approach. Due to the stability of the electronic components, it is possible to simplify the driving scheme so that the regulation is reduced to the comparison of the time integrals of the two consecutive intervals, during which the polarity of the signals is reversed. So the integration after every polarity reversal of

the driving signals can be interrupted in such a way that the integration capacitor is discharged and the integration process restarted. Using this approach, only one comparator is needed instead of two and the differential amplifier is not necessary any more. However two additional analogue switches have to be included, one of them being used for the selection of the electric driving signal from one of the electrodes of the LCD electrooptic switching element 1 and the other one for the discharging the integration capacitor. The general performance of this simplified solution is very similar to the above-described preferred embodiment #1, however the realization of the electric circuitry by itself is somewhat simpler. In order to make the comparison easier, all of the electronic elements and subassemblies in the following discussion, which perform the same function, are marked with the same numbers as in the preferred embodiment #1 (up to and including No. 47)

The block diagram of such an electronic driving circuitry for the driving of the LCD electrooptic switching element 1 is illustrated in figure 5, while the most relevant electric signals are shown in figure 6.

In this case the driving electric circuitry, which provides the long-term compensation of the DC voltage component of the electric driving field, is constructed in such a way that the driving signals (V_{LCD1} and V_{LCD2} in Fig.6) on the electrodes 2 and 3 of the LCD electrooptic switching element 1 are connected to the inputs 49 and 50 of the analogue switch 48. Synchronously with the logic electric driving signals for the appropriately selected driving electrode of the LCD electrooptic switching element 1, which are connected to its control input 58, the analogue switch 48 selects one the two electric potentials of the driving signals and connects it via the output 51 to the input 8 of the integrator 9. The output signal 10 (Int in Fig.6) of the integrator 9 is connected to the comparation input 56 of the comparator 54. Since the reference input 55 of the comparator 54 is connected to the electrical potential V_C, the signal which is generated by the comparator 54 at its output 57 (Cmp in Fig.6), enables the control over the electric driving signals (V_{LCD1} and V_{LCD2} in Fig.6.) for the LCD electrooptic switching element 1 in such a way that the integral of the DC component of the said electric driving field never exceeds the allowed value. At the same time the signal, which is generated at the output 57 of the comparator 54, which is also connected to the select input 61 of the analogue switch 60, drives the said switch in such a way that with each signal generated by the comparator, corresponding at the same time to the polarity change of the electric driving signals for the LCD electrooptic switching element 1, via its input 63, which is connected to the appropriate electric potential V_P, discharges the integration

capacitor of the integrator 9. So the time integration of the electric driving field is restarted and so the next time interval with the reverse polarity of the electric driving signal has the same time integral as the previous one. This results in a complete compensation of the long-term DC voltage component of the electric driving field. The time dependence of the electric driving signals for the LCD electrooptic switching element 1 is determined by the comparator 54, its output 57 being connected to the input 16 of the "flip/flop" circuitry 17. Under its control the "flip/flop" circuitry 17 generates the driving signals (FF_Q in Fig.6. and FF $\bar{Q}$) at its outputs 18 and 19 for each of the electrodes of the LCD electrooptic switching element 1 respectively, so that they are phase shifted for 180° (Q/ $\bar{Q}$). The logic control signals at the outputs 18 and 19 of the "flip/flop" circuitry 17 are connected to the inputs 39 and 40 of the voltage translator 36 which transforms them into the electric driving signals for the LCD electrooptic switching element 1 with the adequately selected amplitude of the said driving signals at its outputs 37 and 38 connected to the control electrodes 2 and 3 of the LCD electrooptic switching element 1.

The time dependence of the amplitude of the electric driving signals for the LCD electrooptic switching element 1, providing for the maximum speed of the activation of the said switching element 1, can be optionally implemented in the above described electric driving scheme by using the analogue switch 42, controlled by the logic circuitry 30, which is in turn controlled by the sensor 35 so that it corresponds to the ideal time dependence presented in the figure 1. This is achieved in such way that the control electrical impulse (Sig in Fig.6), which is generated by the sensor 35 at its output 34, connected to the input 31, activates the logic circuitry 30. The said logic circuitry via the outputs 33 of the control bus, connected to the control inputs 44 of the analogue switch 42, selects between the voltages (V_{SW}, V_{SH}, V_{TH}), which are connected to the inputs 45, 46, 47 of the analogue switch 42. The selected voltage V_{LCD} at the output 43 is connected to the driving input 41 of the voltage translator 36. The voltage translator changes the amplitude of the logic signals which are connected to the inputs 39 and 40 and transforms them into the driving signals for the LCD electrooptic switching element 1 with the amplitude equal to the voltage on its control input 41. So the amplitude of the electric driving signals on the control electrodes 2 and 3 of the LCD electrooptic switching element 1 adopts the appropriate time dependence (Fig.1) in accordance with the electric control impulse (Sig in Fig.6), allowing for the maximum switching speed of the LCD electrooptic switching element 1.

The above described driving scheme for the driving of the LCD electrooptic switching element 1, due to large differences in the amplitudes of the driving signals on the electrodes

2 and 3 of the LCD electrooptic switching element 1, can cause significant differences in duration times for different driving voltage levels with the said electric driving signals. Therefore it is useful to optionally change the reference voltage level on the input 55 of the comparator 54 according to the signal generated by the sensor 35 at its output 34, which marks the activation period of the switching element, in such a way that the time-intervals of the polarity change of the electric driving signals are as uniform as possible. The appropriate selection of the reference voltage on the input 55 of the comparator 54 is provided by the logic control circuitry 30, in accordance with the signal generated by the sensor 35 on its output 34 connected to the input 31 of the said control circuitry 30 and in accordance with the digital driving signal for the LCD electrooptic switching element 1, which is connected via the output 19 of the "flip/flop" switching circuitry 17 to its synchronization input 59. So the logic circuitry 30 via its output 32 connected to the control input 26 controls the analogue switch 24. The analogue switch 24 synchronously with the signal of the sensor 35, marking the time period of the activation of the LCD electrooptic switching element 1 and the digital control signal for the said LCD electrooptic switching element 1, selects between the voltage levels V_{S1} and V_{S2}, connected to the inputs 27 and 28 of the analogue switch in such a way that the reference voltage level V_C is appropriately selected synchronously with the selected digital driving signal 19 for the LCD electrooptic switching element 1. This results in the fact that every direct current voltage compensation process is carried on to the end. The analogue switch 24 connects the selected voltage V_C via its output 25 to the reference input 55 of the comparator 54 (V_{COMP} in Fig.6.). Significant increase of the symmetry of the electric driving signals for the LCD electrooptic switching element 1 is possible by using the adequate ratio between the voltage levels V_{S1} and V_{S2}.

Preferred embodiment 3:

The regulation of the electric driving signals based on the time integration of the electric driving voltage between the driving electrodes of the LCD electrooptic switching element 1, as described in the preferred embodiment #2, can be further simplified, if some additional assumptions can be made. Assuming that the voltage translator 36 is operating ideally (meaning that there is no significant difference between the voltage on the electrodes of the LCD electrooptic switching element 1 and the supply voltages V_{SW}, V_{SH}, V_{TH} of the translator 36) and that the currently selected active driving electrode is connected to one of the driving potentials (V_{SW}, V_{SH}, V_{TH}) while the other one is at the same moment connected always to the same potential (for example V_{GND}, V_{SS}, V_{DD}), then the selection switch 48, shown in figure 5, is not necessary. The input 8 of the integrator 9 can be directly connected to the

driving electric potential at the output 43 of the analogue switch 42 that selects between the driving electric potentials V_{SW}, V_{SH}, V_{TH}. The output 43 of the said analogue switch 42 is further connected to the power supply input 41 of the voltage translator 36.

The block diagram of such simplified circuitry for the driving of the LCD electrooptic switching element 1 is illustrated in figure 9, while the most relevant electric signals in such circuitry are illustrated in figure 6.:

The simplified electric circuitry which provides the long-term compensation of the DC voltage component of the electric driving field is constructed in such a way that the output electric driving signals (V_{LCD1} and V_{LCD2} in Fig.6) at the outputs 37 and 38 of the voltage translator 36 are connected only to the electrodes 2 and 3 of the LCD electrooptic switching element 1. The voltage output 43 of the analogue switch 42 is connected to the input 41 of the voltage translator 36 as well as directly to the input 8 of the integrator 9. The output signal 10 (Int in Fig.6) of the integrator 9 is connected to the comparation input 56 of the comparator 54. Since the reference input 55 of the comparator 54 is connected to the electrical potential V_C, the signal, which is generated by the comparator 54 at its output 57 (Cmp in Fig.6), enables the control over the electric driving signals (V_{LCD1} and V_{LCD2} in Fig.6) for the LCD electrooptic switching element 1 in such a way that the time integral of the DC component of the said electric driving field never exceeds the allowed value. At the same time the signal, generated at the output 57 of the comparator 54, and also connected to the select input 61 of the analogue switch 60, drives the said switch in such a way that the said switch 60, with each signal generated by the comparator, corresponding at the same time to the polarity change of the electric driving signals for the LCD electrooptic switching element 1, discharges the integration capacitor of the integrator 9 by connecting it to the appropriate electric potential V_P, at its input 63. So the time integration of the electric driving field is restarted and the next time interval with the reverse polarity of the electric driving signal must have the same time integral as the previous one. This results in a complete compensation of the long-term DC voltage component of the electric driving field. The time dependence of the electric driving signals for the LCD electrooptic switching element 1 is determined by the comparator 54, its output 57 being connected to the input 16 of the "flip/flop" circuitry 17. Under its control the "flip/flop" circuitry 17 generates the driving signals (FF_Q in Fig. 6 and $FF_{\bar{Q}}$) at its outputs 18 and 19 for each of the electrodes of the LCD electrooptic switching element 1 respectively, so that they are phase shifted for 180° (Q/ $\bar{Q}$). The logic control signals at the outputs 18 and 19 of the "flip/flop" circuitry 17 are connected to the inputs 39 and 40 of the voltage translator 36, which transforms them into the electric driving signals for the LCD electrooptic

switching element 1 with the adequately selected amplitude of the said driving signals at its outputs 37 and 38 connected to the control electrodes 2 and 3 of the LCD electrooptic switching element 1.

The time dependence of the amplitude of the electric driving signals for the LCD electrooptic switching element 1, providing for the maximum speed of the activation of the said switching element 1, can be optionally implemented in the above described electric driving scheme by using the analogue switch 42, controlled by the logic circuitry 30, which is in turn controlled by the sensor 35 so that it corresponds to the time dependence presented in the figure 1. This is achieved in such a way that the control electrical impulse (Sig in Fig.6), generated by the sensor 35 at its output 34 connected to the input 31, activates the logic circuitry 30. The said logic circuitry 30 via the outputs 33 of the control bus, connected to the control inputs 44 of the analogue switch 42, selects between the voltages (V_{SW}, V_{SH}, V_{TH}), which are connected to the inputs 45, 46, 47 of the said analogue switch 42. The selected voltage V_{LCD} at the output 43 is connected to the driving input 41 of the voltage translator 36. The voltage translator changes the amplitude of the logic signals, connected to the inputs 39 and 40 and transforms them into the driving signals for the LCD electrooptic switching element 1 with the amplitude equal to the voltage on its control input 41. So the amplitude of the electric driving signals on the control electrodes 2 and 3 of the LCD electrooptic switching element 1 can be varied within the required time sequence (Fig.1.) in accordance with the electric control impulse (Sig in Fig.6.), marking the period of the activation of the LCD electrooptic switching element 1, allowing for the maximum switching speed of the LCD electrooptic switching element 1.

The electronic control circuitry, as described in the preferred embodiment #3, can be optionally upgraded in such a way that it can compensate for the time variations in the driving of the LCD electrooptic switching element 1 resulting from the variations of the amplitude of the electric driving signals on the electrodes 2 and 3 of the LCD electrooptic switching element 1 while the comparation voltage V_C is kept constant. Due to the differences in the duration of the individual driving levels it is possible, in accordance with the signal generated by the sensor 35 at its output 34, marking the activation period of the LCD electrooptic switching element 1, to change the reference voltage level at the input 55 of the comparator 54 in such a way that the time-intervals of the polarity change of the electric driving signals are as uniform as possible. The appropriate selection of the reference voltage level at the input 55 of the comparator 54 is provided by the logic control circuitry 30 in accordance with the signal of the sensor 35 the output 34 of which is connected to its

control input 31 as well as with the digital control signal for the LCD electrooptic switching element 1 connected from the output 19 of the "flip/flop" switching circuitry 17 to its synchronization input 59. The logic control circuitry 30 in turn drives the analogue switch 24 via its output 32 connected to the control input 26 of the said analogue switch. The analogue switch 24 synchronously with the signal of the sensor 35, marking the time period of the activation of the LCD electrooptic switching element 1 and the digital control signal for the said LCD electrooptic switching element 1, selects between the voltage levels V_{S1} and V_{S2}, connected to the inputs 27 and 28 of the analogue switch in such a way that the reference voltage level V_C is appropriately selected synchronously with the selected digital driving signal 19 for the LCD electrooptic switching element 1. This results in a fact that every DC voltage compensation cycle is completed. The analogue switch 24 connects the selected voltage V_C via its output 25 to the reference input 55 of the comparator 54 (V_{COMP} in Fig.6.). Significant increase of the symmetry of the electric driving signals for the LCD electrooptic switching element 1 is possible by using the appropriate selection of the ratio between the voltage levels V_{S1} and V_{S2}.

The electronic circuitry for the long-term compensation of the DC voltage component of the electric driving field based on the time integration of the difference between the electric driving signals, as described in the preferred embodiments 1, 2 and 3, can be upgraded by means of using the additional time delay of one of the driving signals as illustrated in figure 7. By using such a relative time delay of one of the driving signals, the electrical power consumption is significantly reduced. The basic deficiency of the standard scheme for driving the LCD electrooptic switching element by using two alternate, essentially identical electric driving signals with amplitude V_0, phase shifted for 180°, for each of the driving electrodes (V_{LCD1}, V_{LCD2} in Fig. 2a) respectively, results from the fact that the electronic driving circuitry with every change of the polarity of the electric driving field for the LCD electrooptic switching element, first has to remove the entire electric charge from the capacitor, represented by the electric capacitance of the LCD electrooptic switching element and then charge it in the opposite sense. This deficiency can be corrected in such a way that with every change of the polarity of the electric driving signals both electrodes of the LCD electrooptic switching element are connected to the same electric potential for the time, which is significantly shorter than the electrooptical response of the LCD switching element (Fig.7), but noticeably longer than the time needed to remove the electric capacitance, which is represented by the LCD electrooptic switching element. This leads to the reduction of the consumption of the electric power by approximately 50%. Such a driving scheme can be realized just by introducing the above described relative time delay between the electric

driving signals V_{LCD1} and V_{LCD2} (Fig.7) in such a way that the electric driving voltage between both electrodes of the LCD electrooptic switching element 1 (V_{LCD}= V_{LCD1} - V_{LCD2}) obtains the required time dependence. The necessary relative time delay of the electric driving signals for the LCD electrooptic switching element 1 is achieved by connecting the logic control signals for the LCD electrooptic switching element 1, generated at the output 18 of the "flip-flop" switching circuitry 17 instead of directly to the input 39 of the voltage translator 36 rather to the input 65 of the delay circuitry 64, which transforms it at its output 66 into a logic driving signal, having identical time dependence, but being adequately delayed (phase shifted) - see Fig. 8. The output of the said delay circuitry 64 is further connected to the input 39 of the volatge translator 36. The time delay is determined by the discharge time constant of the capacitor, corresponding to the electric capacitance of the LCD electrooptic switching element 1 and has to be significantly shorter than time-constant of the dynamics of its electrooptic response. Since the typical values of the discharge time-constant for the capacitor, represented by the electric capacitance of the LCD electrooptic switching element range from a few microseconds to several ten microseconds, while the time-constants of the electrooptic response are typically longer than a few milliseconds, this condition can be easily fulfilled.

The implementation of the integrator circuit - as shown with the block 201 in the Fig. 9 - for the driving signals of the LCD electrooptic switching elements, as well as the implementation of the comparator and the discharging circuit for the capacitor within the integrator -as presented with the block 202 in Fig. 9 – in principle conform to the requirements for the minimal power consumption, which is in directly correlated with relatively slow time variations of the polarity of the controlling signals.

Integration – block 201 in Fig.9: With relatively high control voltages, necessary for the LCD electrooptic switching element, the standard approach to the integration using operational amplifiers as an integrator with a large time constant is not applicable, since it consumes too much power. Large time constant can be effectively achieved by integrating the control voltage for the LCD electrooptic-switching element only periodically for a short time but still frequently enough. This means that the repetition period for integrating should be short enough not to introduce significant errors due to the unsynchronized change of the amplitude of the control signals for LCD electrooptic switching element. In the application the error should be less than 10%. Instead of charging the integrating capacitor 110 in the Fig. 10, with a DC current proportional to the driving signal for LCD electrooptic switching element, a charge proportional to the control voltage V_{LCD} for the LCD electrooptic switching element is periodically transferred to it. The charge is transferred to the integrating capacitor

110 by the transfer capacitor 101; its capacitance is much smaller than the capacitance of the integrating capacitor 110. Such a transfer of the charge can be achieved by the use of the electronic analogue switches 102 and 103, which toggle the transfer capacitor 101 periodically between the signals for the LCD electrooptic switching element (the transfer capacitor 101 is connected between the switch inputs 104 and 106) and inputs 108 and 109 to the integrator circuit 111 (the transfer capacitor 101 is connected between the switch outputs 105 and 107). The circuitry 111 must assure the complete transfer of the charge from the transfer capacitor 102 to the integrating capacitor 110, when the switches 102 and 103 are in the corresponding positions. The electronic analogue switches need a clock signal V_{CLK} 113 for toggling, typically a square wave with a suitable frequency and a duty cycle of roughly 50%; the current value of the said clock signal determines the positions of both switches at the same time. The frequency of the control signal V_{CLK} is of the order of 100 Hz.

The circuit 111 assuring the complete transfer of the charge from the transfer capacitor 101 to the integrating capacitor 110, can be an amplifier with a gain of one. Also here the amplifier can not be built by an operational amplifier, since an operational amplifier consumes too much power. More suitable circuit 111 can be implemented by the use of two transistors 115 and 116 of the opposite polarity: NPN and PNP, which have their base leads interconnected and represent the input 108 to the circuit 111. Both emmiter leads of these transistors are interconnected as well and represent the input 109 to the circuit 111. The remaining collector leads of both transistors are connected to the ground and the power supply respectively - see Fig. 11. The integrating capacitor 110 is connected between the input 108 of the circuit 111 and the ground. The output 112 of the circuit 111 represents the voltage across the integrating capacitor 110.The charge on the transfer capacitor 101 causes one of the transistors 115 or 116 to conduct, depending on the polarity of the charge at the transfer capacitor 101, which in tum results in the charge transfer from the transfer capacitor 101 into the integrating capacitor 110. The advantage of such circuitry is that the same charge, as brought by the transfer capacitor 101, is consumed from the power supply by one of the two transistors only during the charge transfer, the rest of the time both transistors are not conducting and thus no power is consumed from the power supply. For operation the circuit needs a power supply V_{CC}.

The comparation and discharging of the capacitor in the integrator as presented by means of the block 202 in the Fig. 9:

The discharge of the integrating capacitor 110, when the voltage across its terminals reaches the predefined value V_C, which in turn causes the polarity reversal of the LCD control signals, would normally be implemented by a standard comparator with an

operational amplifier and a discharge unit; the same function can be implemented by the use of two transistors 117 and 118 of the opposite polarity NPN and PNP, where the base lead of the transistor with one polarity is connected to the collector lead of the transistor with the opposite polarity, Fig. 12. The emmiter lead of the PNP transistor 117 represents an input to the comparator 54, while the interconnected base lead of the PNP transistor 117 and the collector lead of the transistor 118 represent the other input 55 to the comparator for the reference value V_C. When the voltage across the integrating capacitor 110 reaches the predefined value, the PNP transistor 117 starts to conduct. This causes the PNP transistor 117 to conduct the electric current, which in turn causes the conduction of the NPN transistor 118. The said transistor 118 reduces the value of the reference voltage so that the PNP transistor 117 keeps conducting until the integrating capacitor 110 is fully discharged. The output from the comparator 57 is implemented by an additional transistor 119, so that the charge impulse during the discharge of the integrating capacitor 110 through the emmiter of the NPN transistor 118 causes the transistor 119 to conduct. This in turn causes the electric impulse to appear at the output 57 of the comparator 54.The discharging of the integrating capacitor 110, implemented in the way described, assures minimal power consumption, since the current is drawn from the power supply through transistors 117, 118 and 119 only during the discharge of the integrating capacitor 110. The comparator circuit needs a power supply V_{CC} for operation as well.

It has to be emphasized that the above-illustrated preferred embodiments represent just three most suitable technical realizations of the proposed patent. Various modifications and changes may be however made to the described embodiments without departing from the spirit and scope of the invention as defined by the appended claims.

Patent claims

1. The driving scheme for the LCD electrooptic elements with alternating square-wave electric signals, the amplitude of which can vary between the different electric levels according to the actual status so that the optimum dynamics of the electrooptic response is assured, characterized in that the changing of the polarity of the electric driving signals is controlled by the integrator, which integrates the potential differences between the electrodes of the LCD electrooptic switching element so that it keeps the value of the time integral of the driving voltages within the predetermined interval allowing for the complete compensation of the long-term DC component of the electric driving field for the LCD electrooptic switching element and that can be optionally complemented with the driving scheme, allowing for the short, spontaneous discharging of the capacitance of the LCD electrooptic switching element at every reversal of the polarity of the driving signals.

2. The driving scheme for the LCD electrooptic switching elements characterized in that with every change of the polarity of the driving signals, both electrodes of the LCD electrooptic switching element are connected to the same electric potential for the time, which is significantly shorter than the electrooptical response of the LCD electrooptic switching element, but longer than the time needed to remove the electric charge from the electrodes of the LCD electrooptic switching element, allowing for the spontaneous discharge of the capacitor represented by the electric capacitance of the LCD electrooptic switching element.

3. The electronic circuitry for the driving of the LCD electrooptic switching element (1) with alternating square-wave driving signals, the amplitude of which can vary between the different electric levels according to the actual status so that the optimum dynamics of the electrooptic response is assured, characterized in that the electric driving signals on the electrodes (2) and (3) of the LCD electrooptic switching element (1) are connected to the difference inputs (4) and (5) of the differential amplifier (6), the output signal (7) of which is connected to the input (8) of the integrator (9) and

that the output signal (10) of the integrator (9) is connected to the comparator inputs (12) and (22) of the comparators (13) and (20), the reference inputs (11) and (21) of which are connected to the electric potentials V_{C2} and V_{C1} respectively, while the signals, generated at the outputs (14) and (23) of the comparators (13) and (20), enable the

control over the logic control signals for the LCD electrooptic switching element (1) via the "set/reset" inputs (16) and (15) of the control "flip/flop" circuit (17) so that the electric driving signals for each of the electrodes of the LCD electrooptic switching element (1), generated at its outputs (18) and (19) are phase shifted by 180° (Q/ $\bar{Q}$) and

that these logic control signals are connected to the inputs (39) and (40) of the voltage translator (36), which transforms them into the driving signals for the LCD electrooptic switching element (1) at its outputs (37) and (38) connected to the control electrodes (2) and (3) of the LCD electrooptic switching element (1), the amplitude of these driving signals being determined by the voltage level V_{LCD}, which is connected to the control input (41) of the voltage translator (36) and

that the said electronic driving circuitry can be optionally complemented with the electronic circuitry for the reduction of the time-interval variations of the polarity change of the electric driving signals for the LCD electrooptic switching element (1) and with the electronic circuitry for the generation of the time/phase delay of the electric driving signals for the LCD electrooptic switching element (1)

4. The electronic circuitry for the driving of the LCD electrooptic switching element with alternating square-wave electric driving signals, the amplitude of which can vary between the different electric levels according to the actual status so that the optimum dynamics of the electrooptic response is assured, according to the claim 3, characterized in that it reduces the time-interval variations of the polarity change of the electric driving signals by means of using the additional analog switch (24) that selects between the voltage levels V_{S1} and V_{S2}, connected to the inputs (27) and (28) of the said analogue switch so that it changes the reference voltage V_{C1} at its output (25), connected to the reference input (21) of the comparator (20) and

that the selection of the reference voltage is made synchronously with the adequately selected driving signal for the LCD electrooptic switching element (1) and according to the signal given by the sensor element (35) so that the signal, which is generated by the sensor (35) at its output (34), connected to the synchronization input (31), synchronizes the logic control circuitry (30) in such a way that the logic signal at its output (32), connected to the control input (26) of the analogue switch (24), controls the said analogue switch in such a way that it selects the voltage level V_{C1} at its output (25), connected to the reference input (21) of the comparator (20), so that the time-interval

variations of the polarity change of the electric driving signals, controlled by the comparator (20), are as small as possible.

5. The electronic circuitry for the driving of the LCD electrooptic switching element with alternating square-wave electric signals, the amplitude of which can vary between different electric voltage levels according to the actual status so that the optimum dynamics of the electrooptic response is assured, characterized in that the electric driving signals on the electrodes (2) and (3) of the LCD electrooptic switching element (1) are connected to the inputs (49) and (50) of the analogue switch (48), the output signal (51) of which is connected to the input (8) of the integrator (9) and

that the output signal (10) of the integrator (9) is connected to the comparator input (56) of the comparator (54), the reference input (55) of which is connected to the electric potential V_C, while the signal generated at the output (57) of the comparator (54) enables the control of the logic driving signals for the LCD electrooptic switching element (1) via the input (16) of the control "flip/flop" switching circuit (17) so that the electric driving signals for each of the electrodes of the LCD electrooptic switching element (1), generated at its outputs (18) and (19) are phase shifted for 180° (Q/ $\bar{Q}$) and that at the same time the output (19) of the switching electronic circuitry (17) is connected to the control input (58) of the analog switch (48), selecting one of the driving electric voltages of the LCD electrooptic switching element (1) and that the output (57) of the comparator (54), is connected to the select input (61) of the analog switch (60), so that with every change of the polarity of the electric driving field between the electrodes of the LCD electrooptic switching element (1) the said analogue switch (60) switches for a short time its output (53), connected to the input (52) of the of the integrator (9), from its electrically floating input (62) to the adequately chosen constant electric potential, connected to its input (63), which results in resetting the integrator (9) to the initial state and

that the logic driving signals at the outputs (18) and (19) of the switching logic circuitry (17) are connected to the inputs (39) and (40) of the voltage translator (36) that transforms them on its outputs (37) and (38), connected to the electrodes (2) and (3) of the LCD electrooptic switching element (1), into the electric driving signals for the said LCD electrooptic switching element (1), the amplitude of which being determined by the electric voltage V_{LCD}, connected to the control input (41) of the voltage translator (36) and

that this electronic circuitry can be optionally complemented with the electronic circuitry for the reduction of the time-interval variations of the polarity-change of the electric driving signals for the LCD electrooptic switching element (1) and with the electronic circuitry for the generation of the time/phase delay of the electric driving signals.

6. The electronic circuitry for the driving of the LCD electrooptic switching element with alternating square-wave electric signals, the amplitude of which can vary between different electric voltage levels according to the actual status so that the optimum dynamics of the electrooptic response is assured, characterized in that the voltage output (43) of the analogue switch (42) which is apart from being connected to the input (41) of the voltage translator (36), connected also directly to the input (8) of the integrator (9) and

that the output signal (10) of the integrator (9) is connected to the comparator input (56) of the comparator (54), the reference input (55) of which is connected to the electric potential V_C, while the signal generated at the output (57) of the comparator (54) enables the control of the logic driving signals for the LCD electrooptic switching element (1) via the input (16) of the control "flip/flop" switching circuit (17) so that the driving signals for each of the electrodes of the LCD electrooptic switching element (1), generated at its outputs (18) and (19) are phase shifted for 180° (Q/ $\bar{Q}$) and

that the output (57) of the comparator (54) is connected to the select input (61) of the analogue switch (60) so that with every change of the polarity of the electric driving field between the electrodes of the LCD electrooptic switching element (1) the said analogue switch (60) switches for a short time its output (53), which is connected to input (52) of integrator (10), from its electrically floating input (62) to the adequately chosen constant electric potential V_p, connected to its input (63), which results in resetting the integrator (9) to the initial state and

that the logic driving signals at the outputs (18) and (19) of the switching logic circuitry (17) are connected to the inputs (39) and (40) of the voltage translator (36) that transforms them on its outputs (37) and (38), connected to the electrodes (2) and (3) of the LCD electrooptic switching element (1), into the electric driving signals for the said LCD electrooptic switching element (1), the amplitude of which being determined by the electric voltage V_{LCD}, connected to the control input (41) of the voltage translator (36) and

that this electronic circuitry can be optionally complemented with the electronic circuitry for the reduction of the time-interval variations of the polarity-change of the electric driving signals for the LCD electrooptic switching element (1) and with the electronic circuitry for the generation of the time/phase delay of the electric driving signals.

7. The electronic circuitry for the driving of the LCD electrooptic switching element with alternating square-wave electric driving signals, the amplitude of which can vary between the different electric levels according to the actual status of the said LCD electrooptic switching element, so that the optimum dynamics of the electrooptic response is assured, according to the claim 5 and claim 6, characterized in that it reduces the time-interval variations of the polarity change of the electric driving signals by using the additional analog switch (24), which selects between the voltage levels V_{S1} and V_{S2} connected to the inputs (27) and (28) of the said analog switch so that it changes the reference voltage V_C at its output (25) connected to the reference input (55) of the comparator (54) and

that the selection of the reference voltage is made according to the signal given by the sensor element (35) and synchronized with the appropriate electric driving signal for the LCD electrooptic switching element (1) so that the signal that is generated by the sensor (35) at its output (34), connected to the synchronization input (31), synchronizes the logic control circuitry (30), which through its output (32), connected to the control input (26) of the analogue switch (24), controls the said analogue switch (24) in such a way that it selects the reference voltage V_C at its output (25), connected to the reference input (55) of the comparator (54), so that the time-interval variations of the polarity change of the electric driving signals, controlled by the comparator (54), are as small as possible.

8. The electronic circuitry for the driving of the LCD electrooptic switching element with alternating square-wave electric driving signals, the amplitude of which can vary between the different electric levels according to the actual status, so that the optimum dynamics of the electrooptic response is assured, according to claims 3, 5, and 6, characterized in that the logic driving signal for the LCD electrooptic switching element (1), which is generated at the output (18) of the "flip/flop" switching circuitry (17), instead of being connected directly to the input (39) of the voltage translator (36), is connected to the input (65) of the delay circuitry (64), the output (66) of which, is connected to the input (39) of the voltage translator (36), so that the logic driving signal is delayed for the

time, which is significantly shorter than the dynamics of the electrooptical response of the LCD electrooptic switching element (1) but longer than the time needed to remove the electric charge from the electrodes of the LCD electrooptic switching element (1).

9. The electronic circuitry for the driving of the LCD electrooptic switching element with alternating square-wave electric driving signals, the amplitude of which can vary between different electric voltage levels according to the actual status of the said LCD electrooptic switching element so that the optimum dynamics of the electrooptic response is assured, characterized in that the integration of the LCD electrooptic switching element driving signals is implemented by the periodic, sufficiently frequent, transfer of the charge proportional to the LCD electrooptic switching element driving voltage, into the integrating capacitor (110) by the transfer capacitor (101) and electronic analog switches (102) and (103), where the complete transfer of the charge from the transfer capacitor (101) into the integrating capacitor (110) is provided by two transistors of the opposite polarity (115) and (116) with base leads interconnected and emmiter leads interconnected.

10. The electronic circuitry for the driving of the LCD electrooptic switching element with alternating square-wave electric driving signals, the amplitude of which can vary between different electric voltage levels according to the actual status of the said LCD electrooptic switching element so that the optimum dynamics of the electrooptic response is assured, characterized in that the comparation of the integral of the LCD control signals with the reference voltage V_C and the discharging of the integrating capacitor (110) is provided by two transistors of the opposite polarity (117) and (118), which have their base leads connected to the collector leads of the other transistor, while remaining emitter leads are connected to the integrating capacitor (110) and the output signal from the circuit is provided by additional NPN transistor (119).

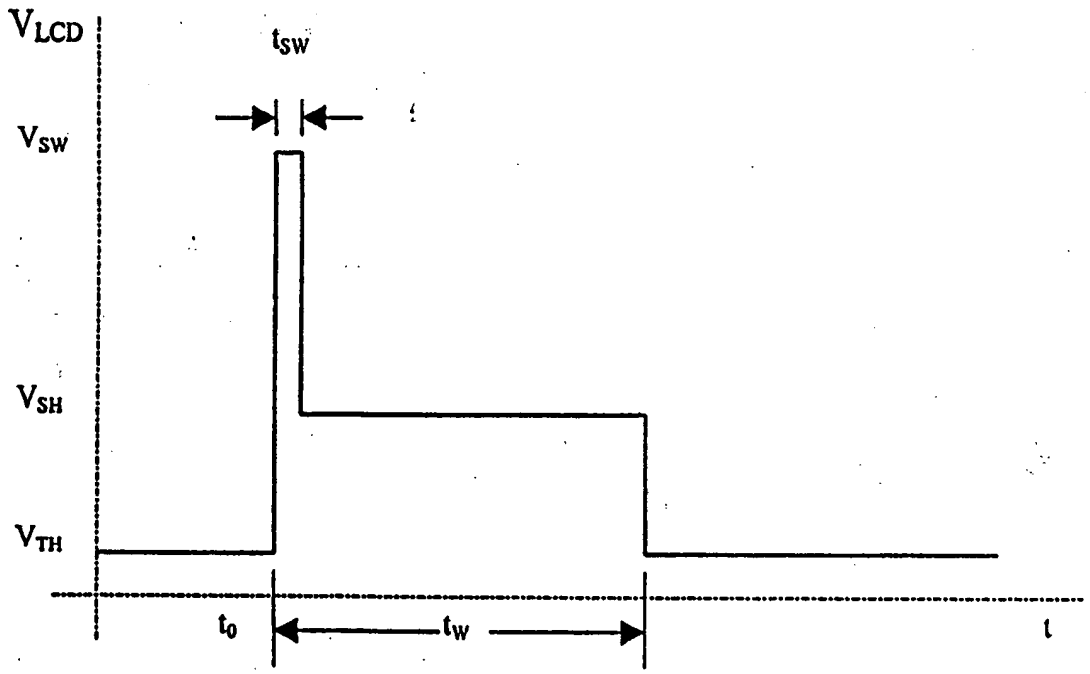


Fig. 1

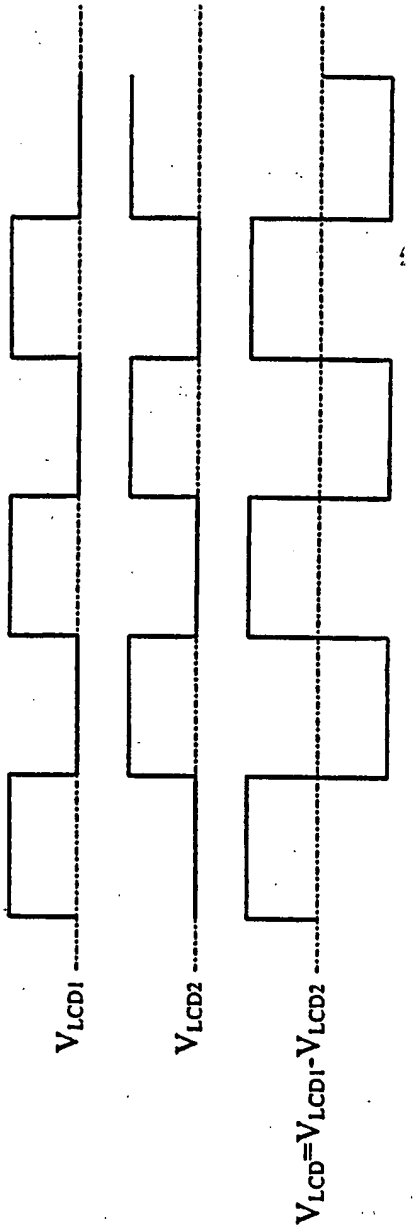


Fig. 2a

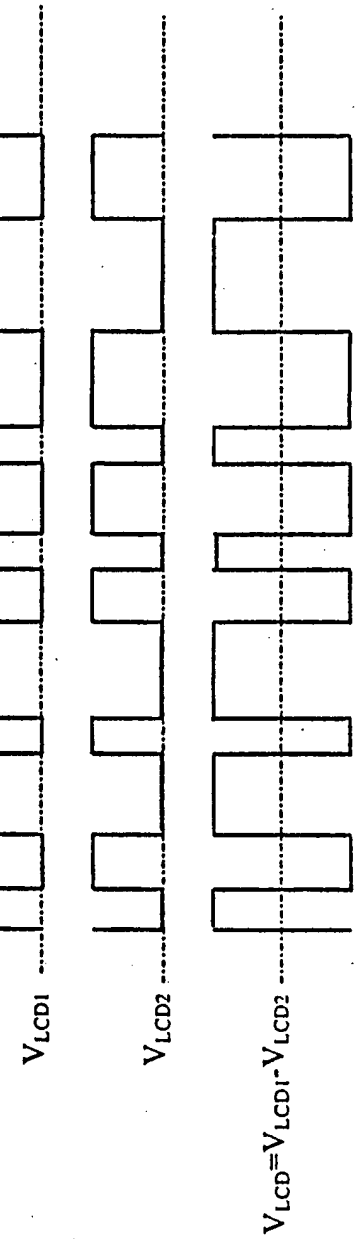
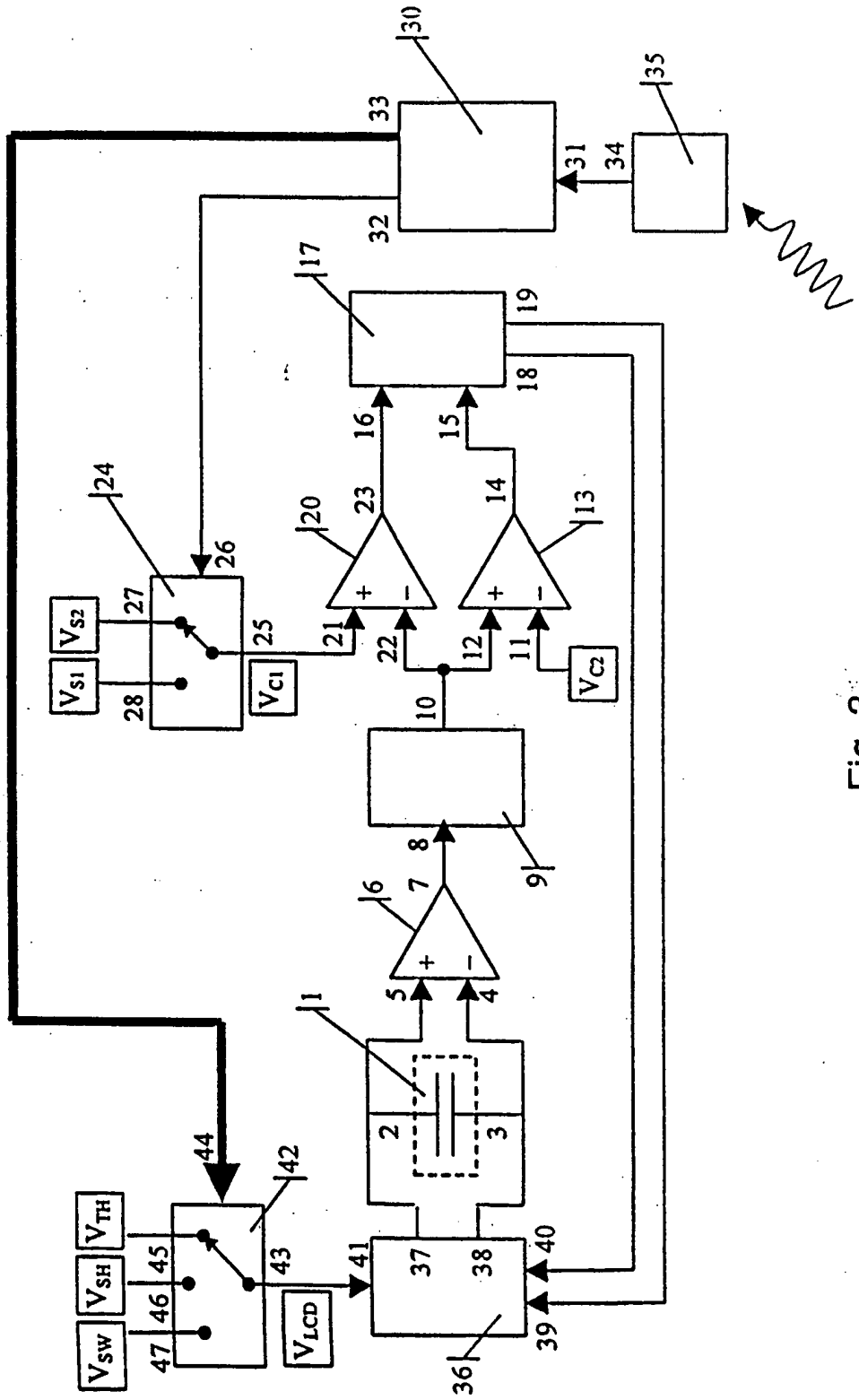


Fig. 2b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V_{S2}
V_{S1}
28
V_{C1}
V_{C2}
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7
6
5
4
1
2
3
44
42
V_{TH}
V_{SH}
V_{SW}
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V_{LCD}
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Fig. 3

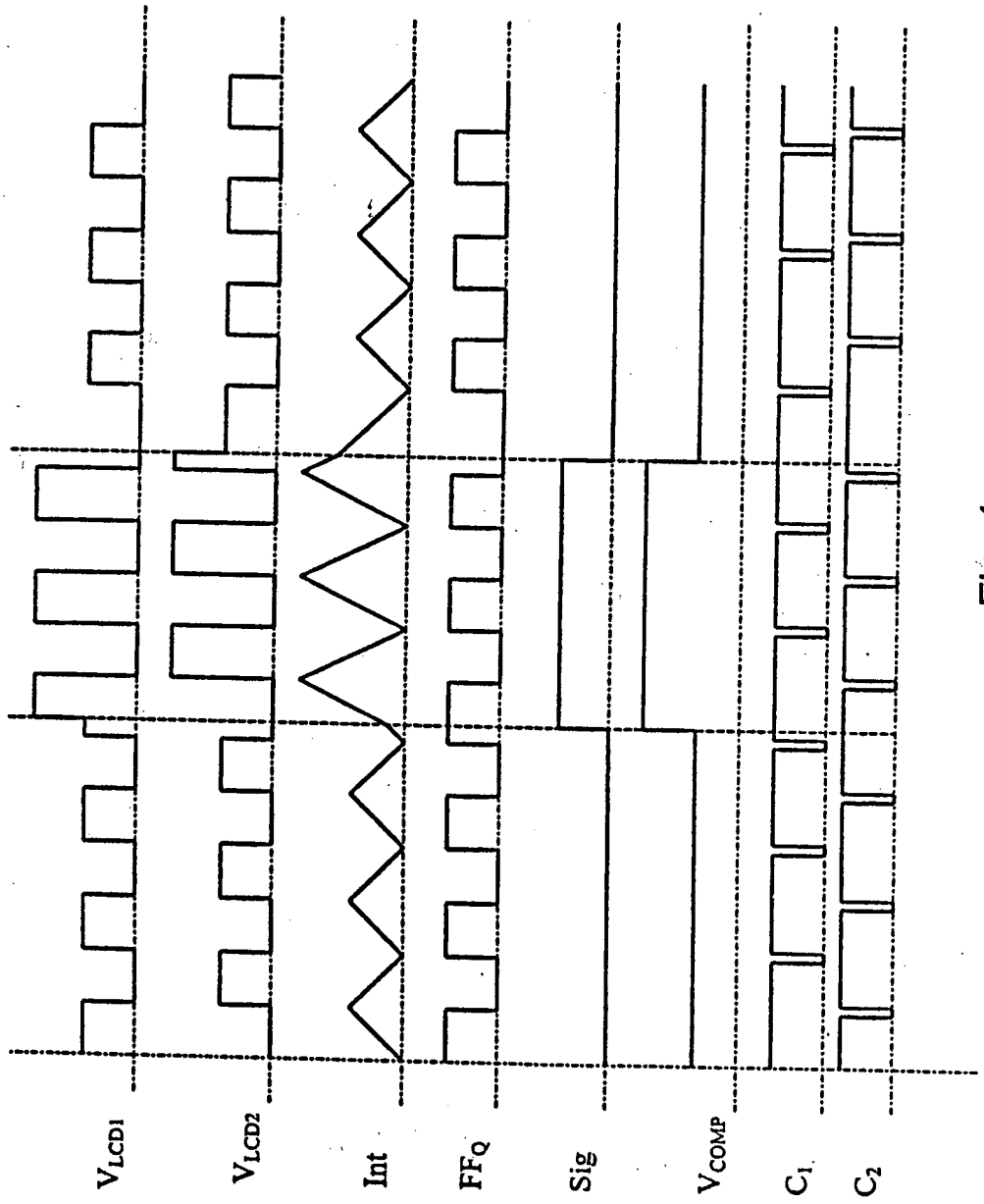
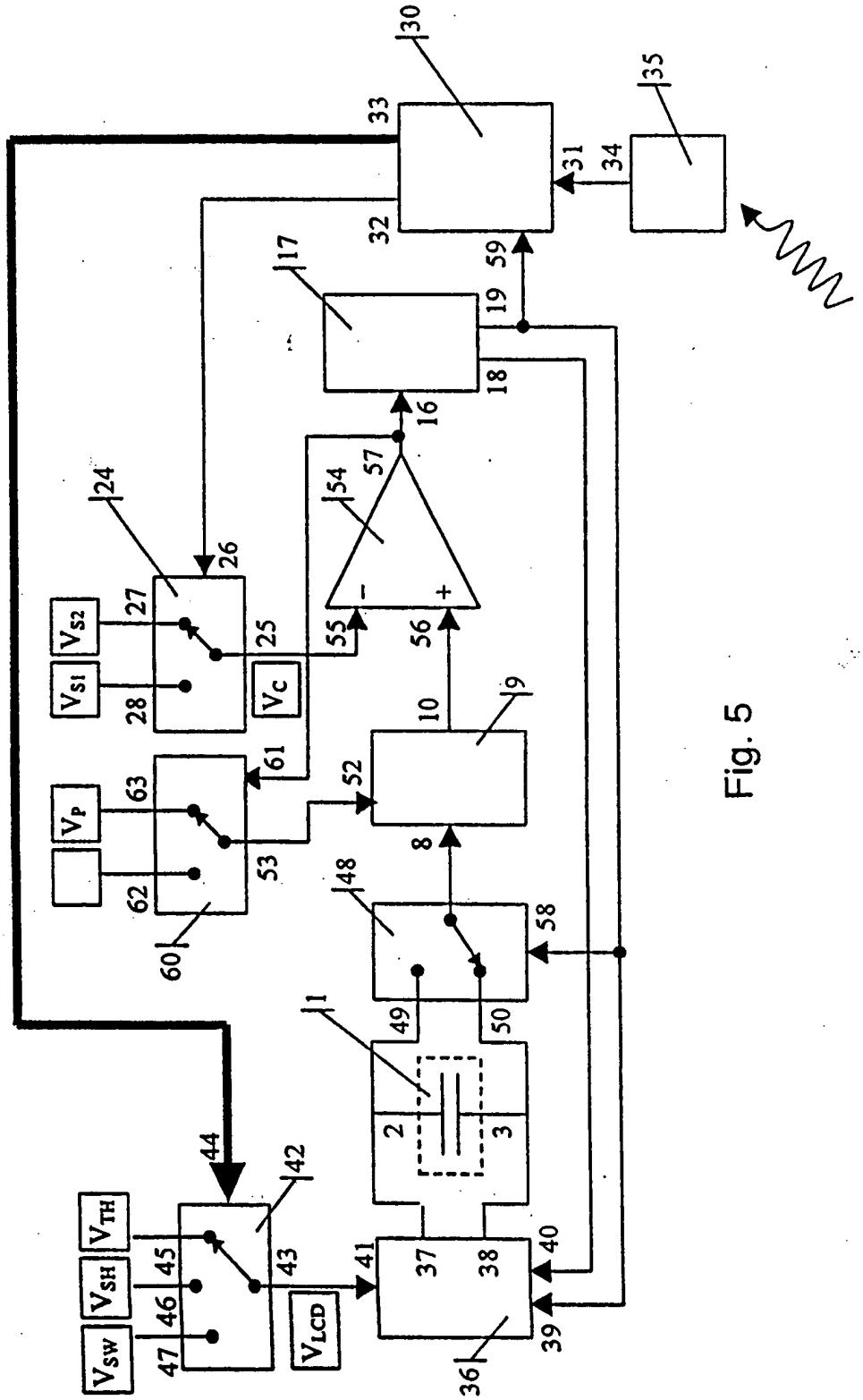


Fig. 4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V_{S2}
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V_C
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V_P
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V_{TH}
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V_{SH}
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V_{LCD}
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Fig. 5

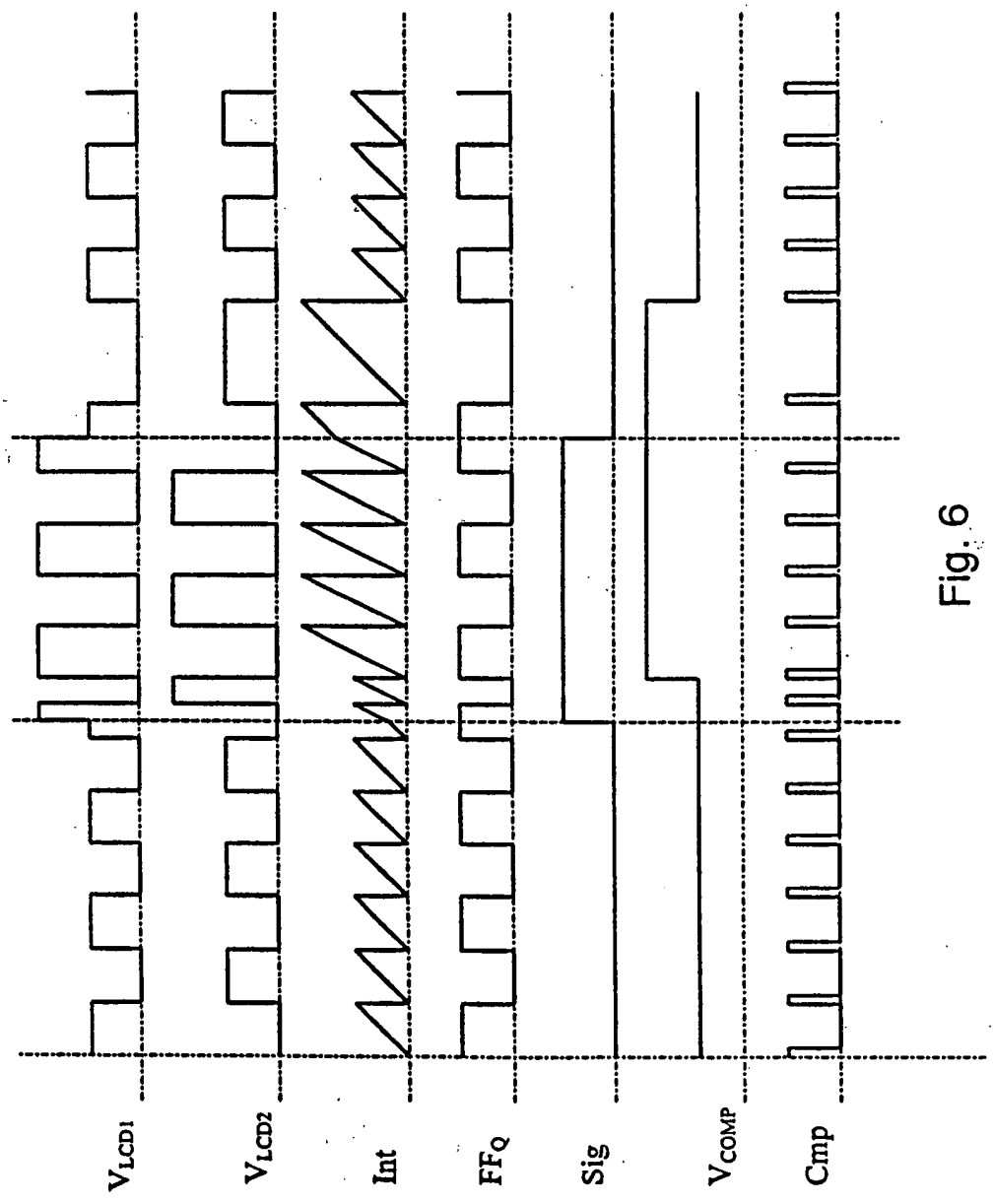


Fig. 6

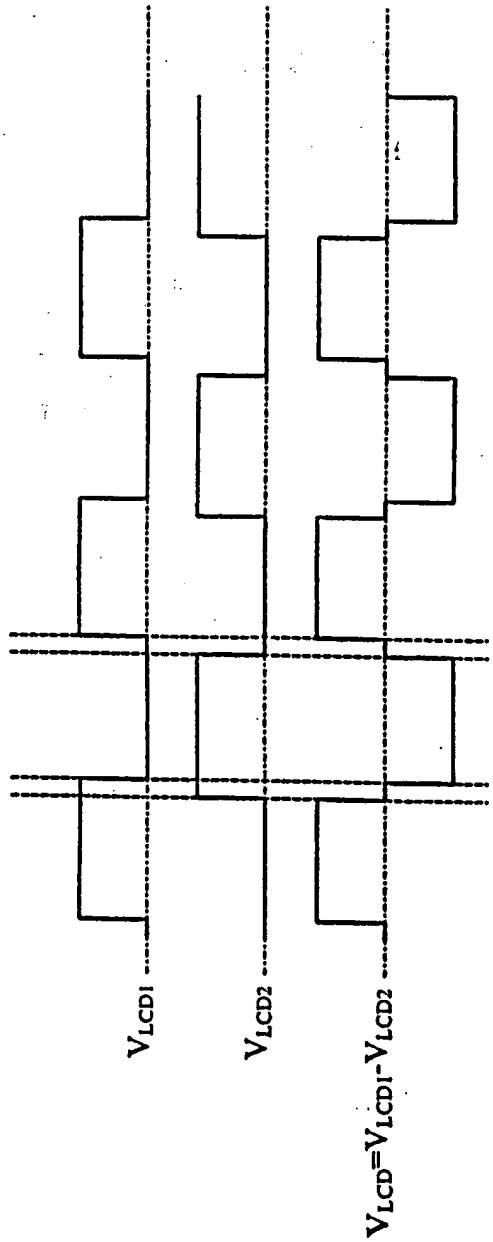


Fig. 7

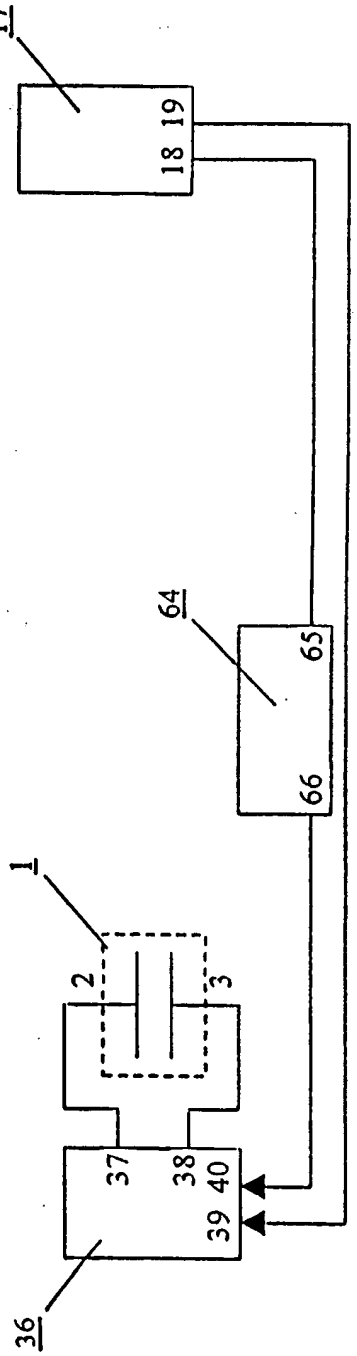
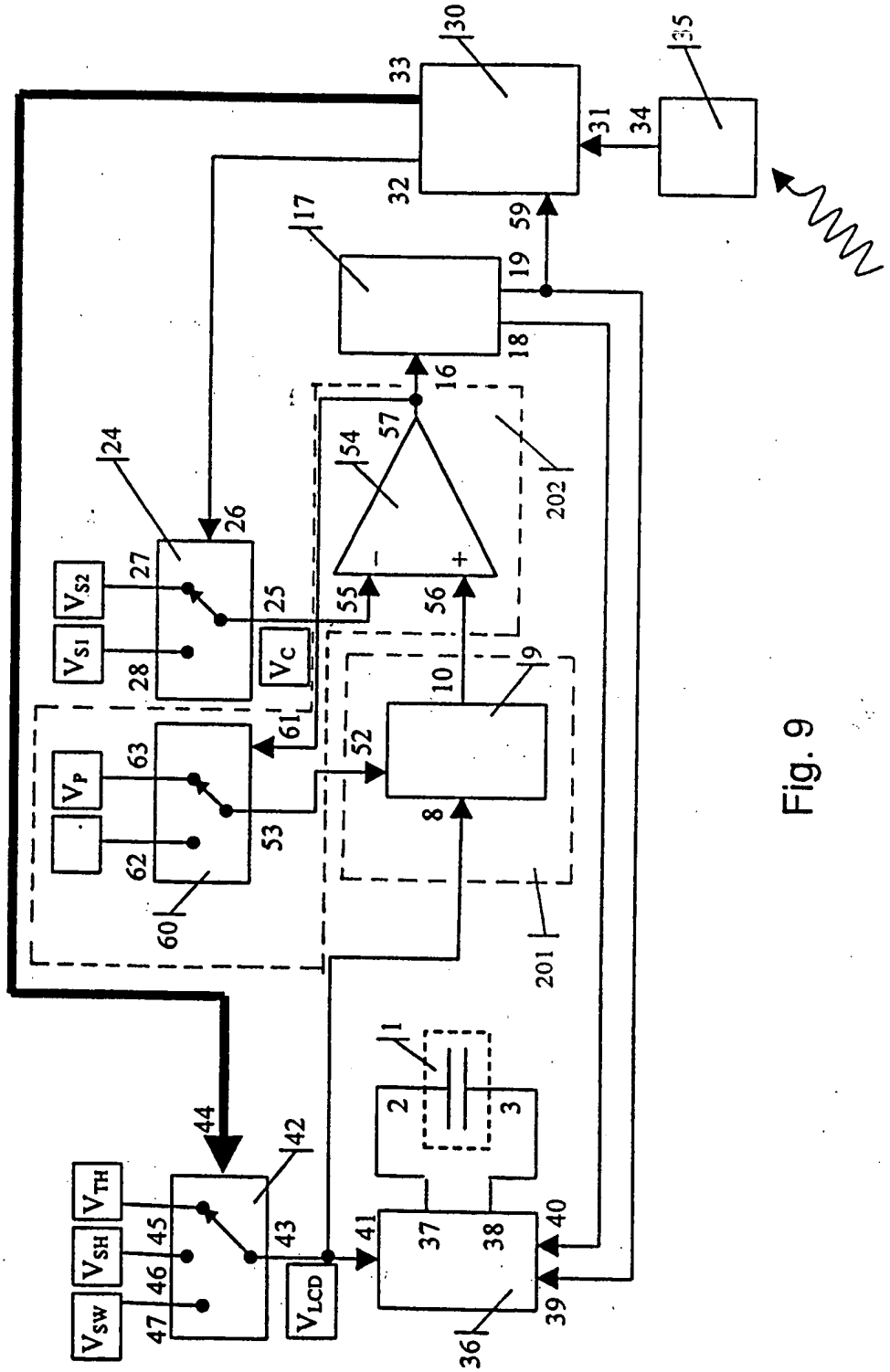


Fig. 8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V_{SH}
V_{SW}
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V_{LCD}

Fig. 9

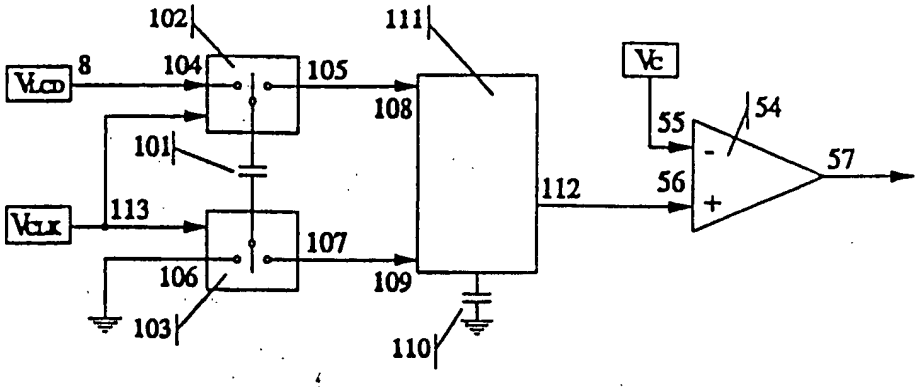

Fig. 10

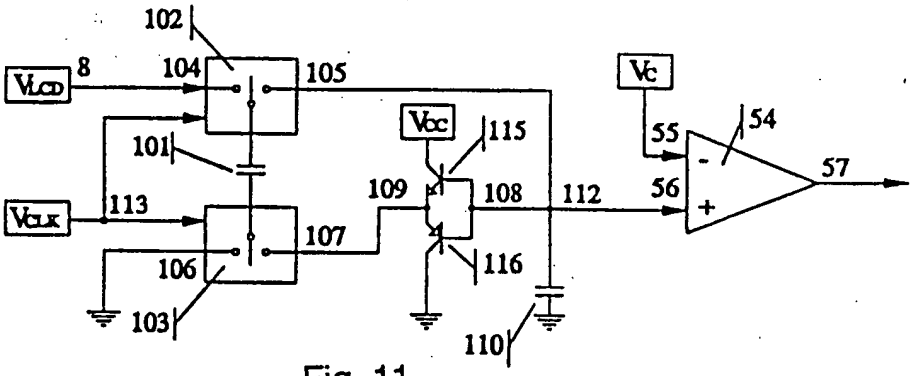

Fig. 11

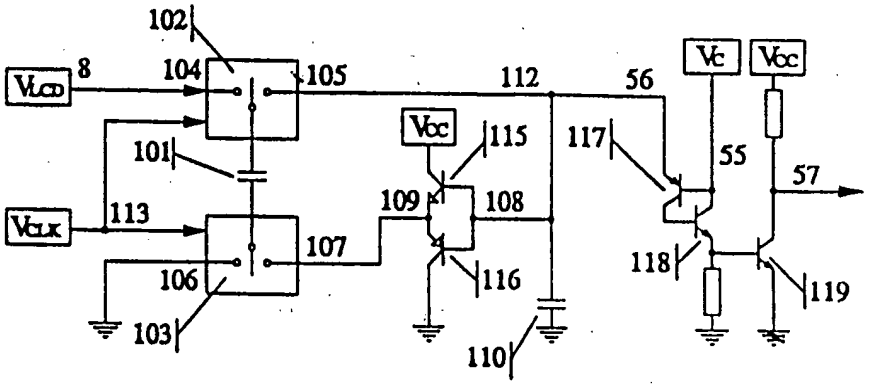

Fig. 12

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(75) Inventor/Applicant *(for US only)*: PONIKVAR, Dušan [SI/SI]; Vodnikova 308a, 1117 Ljubljana (SI).

(74) Agent: ITEM, poslovno svetovanje, d.o.o.; Resljeva 16, 1000 Ljubljana (SI).

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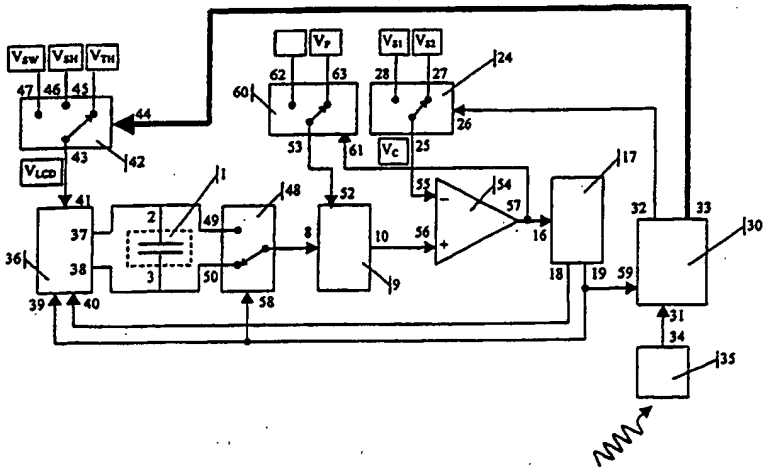
24 August 2000 (24.08.00)

(54) Title: DRIVING SCHEME AND ELECTRONIC CIRCUITRY FOR THE LCD ELECTRO-OPTICAL SWITCHING ELEMENT



(57) Abstract

The invention relates to the problem of the driving of the LCD electrooptic-switching element (1) with alternating, square-wave electric signals, the amplitude of witch can vary between different voltage levels in correspondence with the actual functioning state of the LCD electrooptic-switching element. The polarity changes of the electric driving signals is controlled by the integrator (9), integrating the difference of the electric potentials on the driving electrodes (2, 3) of the LCD electrooptic-switching element, in such a way that the value of time integral of the driving electric field is always kept within a selected interval. Besides this the time dependence of the electric driving signals can be optionally modified so that with every change of the polarity of the electric driving signals, the potentials on both driving electrodes get the same value for a time, which is significantly shorter than the switching time of the LCD electrooptic switching element.

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INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/SI 99/00024

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G02F1/133 G09G3/36 A61F9/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G02F G09G A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 205 311 A (KUTARAGI KEN) 27 May 1980 (1980-05-27) column 4, line 42 -column 5, line 48; figures 8-10 ---	1,3,4,6, 9
A	"METHOD TO MEASURE AND REDUCE UNBALANCED DC VOLTAGE IN ACTIVE MATRIX LCDS" IBM TECHNICAL DISCLOSURE BULLETIN,US,IBM CORP. NEW YORK, vol. 35, no. 3, 1 August 1992 (1992-08-01), pages 162-164, XP000326220 ISSN: 0018-8689 the whole document --- -/--	1,3,5,6

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
5 June 2000	15.06.00

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Stang, I

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INTERNATIONAL SEARCH REPORT

Intern. nal Application No
PCT/SI 99/00024

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 07, 31 July 1996 (1996-07-31) & JP 08 082785 A (SONY CORP), 26 March 1996 (1996-03-26) abstract	1,10
A	WO 87 01468 A (CONS TECHNOLOGY PTY LTD) 12 March 1987 (1987-03-12) page 8, line 3 -page 9, line 2; figures 4,5	1,3,5
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X	US 3 961 840 A (SHIGURI MOROKAWA ET AL) 8 June 1976 (1976-06-08) column 1, line 23 - line 68 column 3, line 37 -column 6, line 39; figures 2F-6	2
A	US 4 279 474 A (BELGOROD BARRY M) 21 July 1981 (1981-07-21) column 6, line 35 -column 7, line 18; figure 7	2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SI 99/00024

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

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2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

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2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

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☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/SI 99/00024

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1,3-10

   LCD driving scheme in which the changing of polarity is controlled by an integrator

2. Claim : 2

   LCD driving scheme in which both electrodes are connected to the same electric potential for a certain period of time

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter. .onal Application No
PCT/SI 99/00024

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